

1994 VEGETATION STUDIES AT

National Training Center, Fort Irwin, California

July, 1996



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ROBERT D. NIEHAUS, INC.

**1994 VEGETATION STUDIES
AT THE NATIONAL TRAINING CENTER
FORT IRWIN, CALIFORNIA**

Prepared under contract with

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SUMMARY

This report presents the results of the vegetation surveys conducted at the National Training Center for the U.S. Army (NTC) in the Central Mojave Desert in the spring and fall of 1994. The 1994 monitoring season was devoted to (1) the description of the plant communities present in selected study plots throughout the NTC, (2) a preliminary evaluation of the response of several vegetation parameters to military impact, (3) the analysis of the sampling protocol used in this study and (4) the establishment of guidelines for the elaboration of a vegetation map of the NTC.

To describe the different vegetation assemblages present on the NTC and to quantify the effect of military training on the ecosystem, several vegetation parameters were measured in eleven study sites. Data used were (1) perennial vegetation cover; (2) perennial vegetation density; (3) perennial and annual vegetation species richness; and (4) herbaceous vegetation frequency and biomass.

Five plant communities were identified: blackbush scrub, blackbush-creosote bush transition, creosote bush scrub, saltbush scrub and desert wash scrub. Differences in vegetation parameters exist in sites between and within plant communities as these parameters depend on topographic factors as well as soil characteristics. The blackbush scrub site had an absolute cover of 43.09 percent, dominated by blackbush (*Coleogyne ramosissima*), and a perennial species richness of 29 species. Sites in the transition zone between blackbush and creosote bush scrub are dominated by creosote bush (*Larrea tridentata*) although other species contribute significantly to the overall cover such as *Ephedra nevadensis* and *Salazeria mexicana* for the Avawatz Mtns. site and

Hymenoclea salsola and *Coleogyne ramosissima* for the Granite Mtns. site. Perennial species richness in these transitional sites was high with 22 and 19 species respectively. Study sites within the creosote bush scrub community are dominated by creosote bush alone or in association with burrobrush (*Ambrosia dumosa*). Percent cover for these sites varies from site to site and ranges from 12.19 percent to 33.70 percent. Overall species richness is lower in creosote bush scrub than in other communities with values between 4 and 6 perennial species for 83 percent of the sites.

Saltbush scrub occurs on the lowlands of drainage basins, Goldstone Lake in this study, where soil and air temperature conditions are responsible for the absence of some desert shrubs, especially creosote bush. *Atriplex confertifolia* is the dominant species in this association followed by *Atriplex polycarpa* and *Artemisia spinescens*. A total of 13 species were recorded for this site, showing an absolute cover of 10.08 percent. The last vegetation assemblage surveyed was desert wash scrub which occurs along washes or runnels. It is a highly variable community, where species composition and cover depend upon the physical characteristics of each individual wash. Cheesebush (*Hymenoclea salsola*) and *Psoralea arborescens* are the dominant shrubs in the wash surveyed for this study. Absolute cover was measured at 25.03 percent and a total of 6 shrub species were recorded.

Data collected for this preliminary study showed that vegetation parameters are adversely affected by the traffic of military vehicles and personnel during the course of training maneuvers. Average perennial vegetation cover is significantly higher (12.99 percent) in the control site than in the heavily impacted site (7.6 percent). Vegetation density showed a

similar response, with an average value of 101.25 individuals for the control plot versus an average density of 21.37 individuals for the impacted site.

To determine the validity of the sampling design, analysis of variance (ANOVA) was performed on absolute cover values and species:area curves were created for each site. Both analyses determined that the number of sampling quadrats per site was sufficient to accurately describe the communities under investigation.

The fourth objective of this study is covered in part II. To develop an efficient method of analyzing and classifying vegetation into plant communities, sampling procedures and several algorithms for analyzing the data base were reviewed. We determined from these studies that cover data collected from line intercepts is an efficient means of collecting reliable quantitative data and that detrended correspondence analysis performed by DECORANA yields a very good classification of the transect data into plant communities.

The level of sampling intensity was determined to be 400 m of line intercept to yield reliable total cover values.

Vegetation mapping should proceed in the following sequence.

1) Plant communities that have not been sampled or where samples are deficient will be quantitatively sampled to develop a complete data set.

2) Selected areas from aerial photographs or videos will be quantitatively sampled, so that correlations between photographic patterns and vegetation can be established.

3) The complete data set will be reanalyzed by DECORANA and the

classification of plant communities finalized.

4) A tabular description of the communities will be finalized for use in field identification of sites.

5) Fort Irwin will be surveyed. During these surveys, vegetation at a site will be classified based on the community descriptions finalized in point 4. Most sites will only require a qualitative assessment of the vegetation. Borderline vegetation and other difficult and dubious vegetation types will require quantitative sampling.

6) Plant community maps will be generated.

INTRODUCTION

Background

The U.S. Army is mandated to comply with environmental regulations derived from Congressional legislation such as the National Environmental Policy Act and the Endangered Species Act (Donnelly and Van Ness, 1986). Compliance with environmental legislation and effective land management require an accurate description of natural resources and their change in response to military land use over time. Since 1987, long term natural resource monitoring studies have been implemented in an increasing number of U.S. Army installations to assist their command in land management decisions and environmental compliance.

At the U.S. Army National Training Center (NTC) in Fort Irwin, California, natural resource monitoring began in 1990. However, a conclusive assessment of natural resource response to military land use was not possible under the original study design. The two main problems with the design were its inability to characterize the major plant communities and wildlife populations at Fort Irwin and the absence of appropriate control sites (Ferrús-García, 1995). In 1994, wildlife and vegetation surveys were conducted at selected study sites in order to describe the different species/ habitat associations present in unimpacted areas at Fort Irwin. A preliminary study of the effects of military training on the ecosystem was conducted in two topographically comparable areas, one not impacted and the other showing training impact. Investigations were also pursued to determine appropriate and efficient vegetation sampling techniques and data analysis procedures for classifying vegetation into plant communities.

description of species/habitat associations in unimpacted areas and the effect military training has had on the ecosystem. Part II deals with the methodology for classifying vegetation into plant communities.

Part I of this report deals with the

PART I

**1994 VEGETATION MONITORING STUDIES
AT FORT IRWIN**

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METHODS

Study sites

Eleven study sites were surveyed between April 15 and June 25, 1994. Nine of these were selected for the description of plant communities and, therefore, situated on undisturbed areas on the NTC. Of the remaining two, one served as the control (unimpacted) treatment and the other as the experimental (severely impacted) treatment in this preliminary training impact analysis. Study sites were named based on their general location, soil parent material (if known) and a qualitative assessment of the plant community present as described in a 1993 floral survey conducted at Fort Irwin (Gibson, Prigge and Niessen, 1994).

Appendix A presents the names of the eleven study sites and corresponding acronyms as well as the location, elevation, slope and aspect of each study site. Appendix B presents the distribution of the sites on the NTC and Goldstone.

Experimental Design

The protocol adopted is an adaption of the design in a previous study of the effects of military training on the Fort Irwin ecosystem (Krzysik, 1985). Such a design is characterized by arbitrary subdivisions of a recognized plant association (study sites/transects) and subsequent random placement of sampling quadrats. It was preferred in this study because it insures even coverage of a selected area while allowing for statistical analysis of the data (Mueller-Dombois and Ellenberg, 1974).

Plant communities were initially identified and representative study sites were located in areas showing the best community development. Figure 1 illustrates the distribution of sampling quadrats within each study site. Two 400-meter long transects (A and B) were evenly placed in each study site and permanently marked. Along each transect, four vegetation strip quadrats

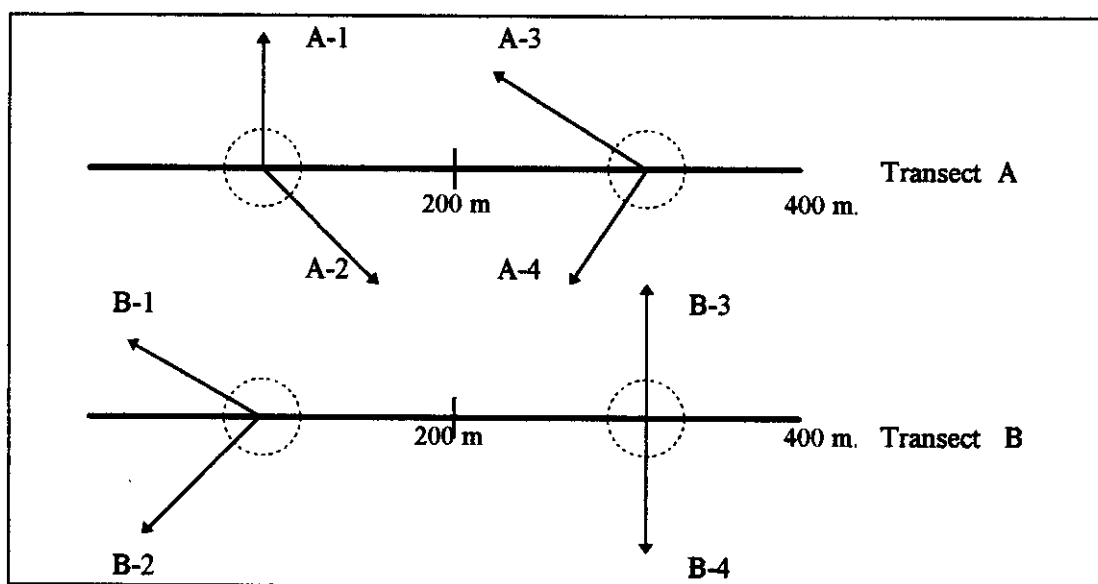


Figure 1. 1994 Vegetation Sampling Experimental Design.

(belt transects) were established, departing from the 100 and 300 meter points with randomly generated angles, two quadrats to the right, the other two to the left of the main transect. Each strip quadrat was 100 meters long and 4 meters wide, except in sites with high vegetation density, where sampling quadrats were 50 x 4 meters. The number of transects and sampling quadrats was the same for nine of the eleven study sites. In the Blackbush Scrub site, the number of sampling quadrats was the same, but the heterogeneity of the habitat precluded placement of the quadrats along the 400 meter transects. Instead, the starting point of each quadrat was selected to insure that the habitat variation was adequately sampled while maintaining the quadrat's random orientation. In the Desert Wash Scrub site, only two strip quadrats were established due to small area encompassed by the wash. These modifications were compatible with the two main elements of the original design: even coverage of a recognized association and random placement of samples for statistical analysis. A total number of 82 strip quadrats was monitored. Improved sophistication of the new study design and intensity of vegetation parameters measurements (refer to following section) precluded the investigators from sampling in 1994 as many belt transects (strip quadrats) as in previous LCTA seasons.

Perennial Vegetation Sampling

Maximum width parallel to the surface (to the nearest 0.1 m) was recorded for all rooted woody and partly woody species and perennial grasses within the strip quadrat. Delineation of desert shrub individuals, especially creosote bush, is a complex and somewhat subjective task. Plants were considered individuals when their canopies were clearly outlined or, in the case of species with clonal growth

patterns, if their foliage was at least 10 cm apart (Krzysik, 1985). Crown cover (cc) was then obtained from the formula $cc = (D/2)^2\pi$, where D equals the measured crown diameter. Since canopies rarely form a perfect circle, a second diameter is usually measured and the average of the two diameters is used in the formula above to obtain a more accurate absolute cover value. In this analysis, cover was expressed as a relative value and collection of a second diameter was not necessary. Limits on time and resource availability played an important role in this decision.

Sampling decisions are common in vegetation ecology methodology due to the inherent variation in plant life forms and morphology. As long as the investigator's judgement is consistent and explained, the method can still be considered satisfactory (Mueller-Dombois and Ellenberg, 1974). In this case, any error overestimating cover is consistent for all transects.

Perennial species dominance was determined based upon two considerations for canopy cover. First, cover is not dependent upon a subjective determination of individual plants and is therefore, a better quantitative measure than density. Second, relative cover is the principal parameter, along with height and spacing of individuals, in plant community classification. Cover has greater ecological significance than density because it gives a better indication of 1) volume of circulating nutrients in the ecosystem, 2) water relations, and 3) shelter and food availability for resident wildlife (Mueller-Dombois and Ellenberg, 1974).

Herbaceous Vegetation Sampling

Herbaceous vegetation species were sampled according to the protocol used in

a long term monitoring study being conducted at the China Lake Naval Weapons Center, California (Leitner and Leitner, 1992). Species frequency and richness and above-ground standing crop were measured on each study site in ninety-six between-shrub and ninety-six under-shrub square-foot (0.09 m^2) plots. The between-shrub plots were randomly located by the biologist by standing at eight meter intervals along each strip quadrat and throwing the sampling frame into an open area. The location of the under-shrub plot for that particular locus was then determined by placing the frame under the shrub nearest the between-shrub plot.

All herbaceous species, except perennial grasses, present within each plot were recorded and clipped at ground level. Herbs with perennial vegetative parts such as *Eriogonum inflatum* were exempt from clipping because of the possibility of severely damaging the plant during the procedure. After collection in the field, the clipped samples were air-dried, and weighed to the nearest 0.01 gram and standing crop recorded as a measure of above-ground biomass.

Data Analysis

Comparisons of vegetation parameters between sites with two levels of military use/disturbance were done using analysis of variance (ANOVA). Two independent analyses were conducted, one on arcsine and square root transformed percent vegetation cover, and the other on square root transformed perennial vegetation density. The actual transformations were: percent cover = arcsine(SQR(percent cover)) and perennial density = SQR(perennial density) (Causton, 1988). These transformations were used because the data did not meet assumptions of homoscedasticity (homogeneity of variances) and because vegetation cover

values were expressed as proportions.

To classify the vegetation assemblages present in each study site into plant communities, we used DECORANA (Hill, 1979). This method of analysis was determined to yield very satisfactory classifications of plant communities, as discussed in part II of this report.

RESULTS AND DISCUSSION

Perennial vegetation sampling

Plant communities

Figure 2 presents the results of the detrended correspondence analysis (DCA) performed by DECORANA on the sites surveyed (relative cover data). Study sites were plotted in relation to the first and second axes of the detrended correspondence analysis which correspond to abiotic parameters that influence species distribution. The abscissa (DCA1) apparently represents soil texture and salinity whereas the ordinate (DCA2) may represent soil fertility (part II, pages 16 and 17). In addition, data corresponding to known plant communities (part II, page 16) were plotted to serve as a reference and to assist in the delineation of the resulting plant associations.

Five clusters, each representing a different community, were recognized: blackbush scrub, blackbush-creosotebush transition, creosote bush scrub, saltbush scrub and desert wash scrub. These communities and the vegetation parameters of the study sites associated with each community are described below.

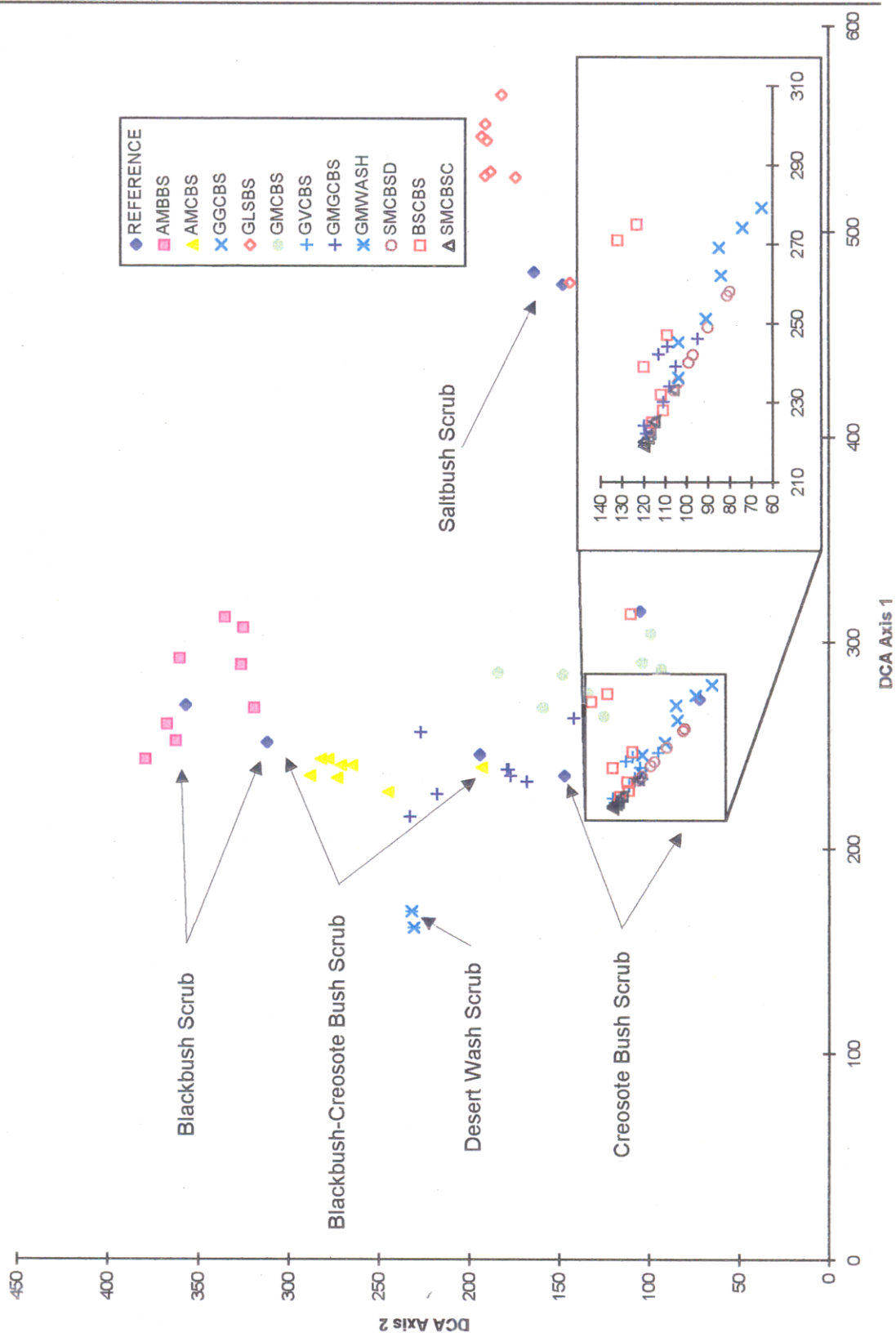


Figure 2. DECORANA of Perennial Vegetation Cover by Sampling Quadrat.

Blackbush Scrub

Blackbush scrub occurs on slopes between 1200 and 1700 meters in elevation. The substrate ranges from gravelly to rocky, and soils from sandy loam to loam. Blackbush, *Coleogyne ramosissima*, is the dominant species in this association with *Ephedra nevadensis*, *E. viridis*, *Hymenoclea salsola*, *Eriogonum fasciculatum* ssp. *polifolium*, *Encelia actonii*, *Lycium andersonii*, *Grayia spinosa* and *Xylorhiza tortifolia* as codominants. Vegetation cover, species composition and species richness of plant communities depend on topographic factors such as

elevation, slope and aspect as well as soil characteristics and vary from site to site within each community. The Blackbush scrub study site, AMBBS, had a vegetation cover of 43.09 percent and 29 perennial species. Figure 3 presents relative cover values for all perennial species contributing more than 2 percent to the overall cover. *Coleogyne ramosissima* was the dominant shrub with 25.74 percent cover whereas *Ephedra nevadensis* and *Grayia spinosa* were the most important codominant species showing relative cover values of 15.11 percent and 11.90 percent, respectively.

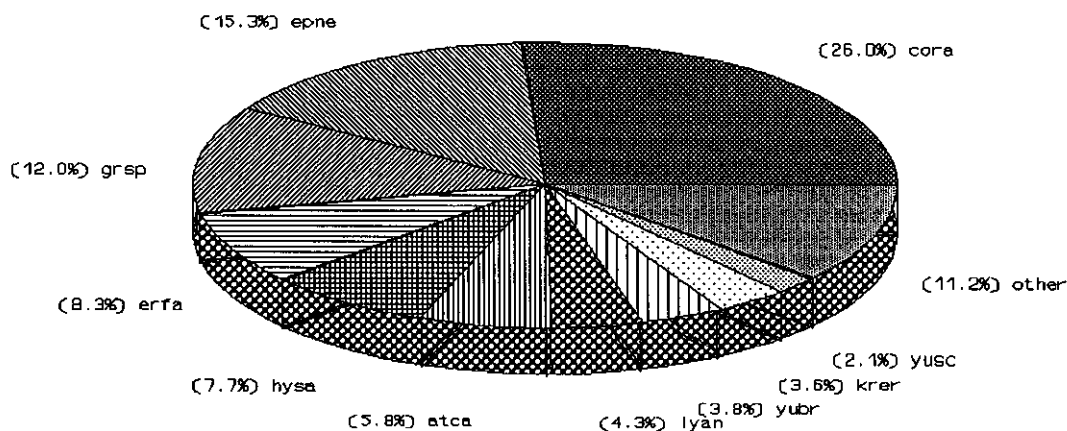


Figure 3. Species Composition for the Avawatz Mtns. Blackbush Scrub Study Site.

Blackbush-Creosote Bush Scrub

This association occurs on upper alluvial fans where the upper limits of creosote bush scrub and the lower limits of blackbush scrub converge. Soils are from sandy loam to loamy sand and decomposed granite is the predominant substrate. Dominance in this ecotonal assemblage is shared among *Coleogyne ramosissima*, *Larrea tridentata* and *Ambrosia dumosa*. Co-occurring shrubs are *Salazeria mexicana*, *Eriogonum fasciculatum* ssp. *polifolium*, *Yucca*

brevifolia, *Encelia* ssp., *Ericameria cooperi*, *Ephedra nevadensis*, *Hymenoclea salsola* and *Krameria erecta*.

Two study sites were present in this community. One, GMGCBBS, was located in the Granite Mountains and the other, AMCBS, in the Avawatz Mountains. Figures 4 and 5 present relative cover values for perennial species contributing more than 2 percent cover as well as conspicuous and ecologically important species such as *Yucca brevifolia* and *Yucca schidigera*. The Granite Mtns. site

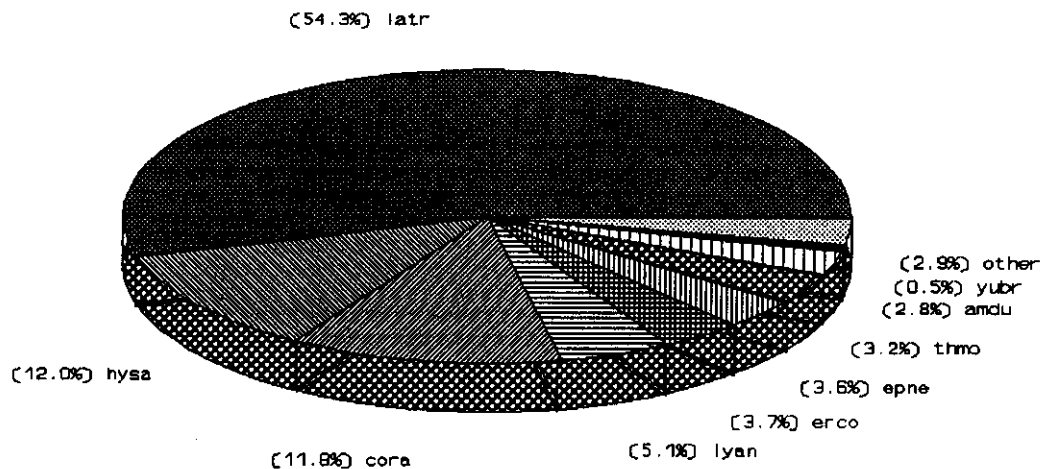


Figure 4. Species Composition for the Granite Mtns. Creosote Bush Scrub Site.

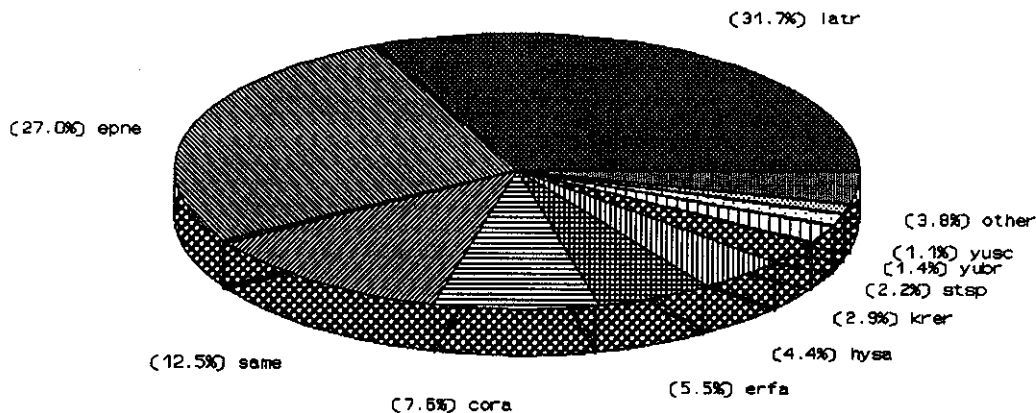


Figure 5. Species Composition for the Avawatz Mtns. Creosote Bush Scrub Site.

had cover of 27.73 percent and a species richness of 19. *Larrea tridentata* was the dominant species with a relative cover of 54.05 percent followed by *Hymenoclea salsola* and *Coleogine ramosissima*, showing relative covers of 11.91 percent and 11.73 percent respectively. The site AMCBS had a higher percent cover, 46.56 percent, and total number of species, 22. Two species dominated in terms of cover: *Larrea tridentata* with a relative cover of 31.73 percent and *Ephedra nevadensis*

with a relative cover of 26.94 percent. This difference in percent cover, shrub diversity and species composition appears to be due to differences in soil texture and moisture, elevation and slope between both study sites. The site GMGCBS was located on a granitic alluvial fan with a 7 percent slope at 1,207 meters in elevation whereas the site AMCBS occurred on strongly dissected fan remnants derived from mixed rock sources with slopes ranging from 5 to 20 percent and an elevation of 1,412 meters.

Creosote Bush Scrub

Creosote bush scrub is the predominant community on Fort Irwin, occurring on alluvial slopes, valley floors and mountain slopes below 1100 meters. Soils are derived from granitic or volcanic parent material and range from loamy sand to sandy loam, being often gravelly or even rocky. *Larrea tridentata* is the dominant species by itself or in association with other shrubs such as *Ambrosia dumosa* or *Pleuraphis rigida*. Common species in this community are *Hymenoclea salsola*, *Krameria erecta*, *Ephedra spp.*, *Lycium andersonii*, *Stephanomeria pauciflora*, *Thamnosma montana*, *Achnatherum speciosum*, *Psoralea argophylla*, *Acamptopappus sphaerocephalus*, and *Grayia spinosa*.

Six of the study sites occurred within this association. As expected, percent cover,

species composition and species richness differed from site to site due to intersite differences in soil properties and topographic factors. The site BSCBS showed the lowest cover, 12.19 percent whereas the site GGCBS site had the highest cover, 33.70 percent. The site with the highest shrub diversity was the GMCBS site with 19 species and the least diverse site was the SMCBS control site with 4 species.

Figures 6 through 10 present relative cover values for all undisturbed sites representative of Creosote Bush Scrub community. The variability of this community is well illustrated by these figures. *Larrea tridentata* relative cover ranges from 83.05 percent in the BSCBS site to 26.95 percent in the GMCBS site whereas *Ambrosia dumosa* shows its lowest relative cover at 9.56 percent (BSCBS site) and its highest at 38.34 percent (GMCBS site).

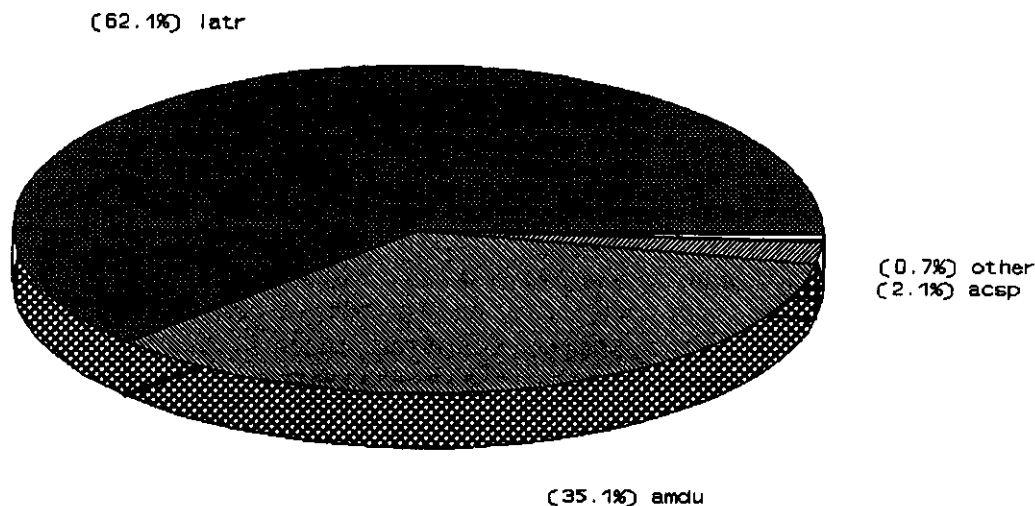


Figure 6. Species Composition for the Goldstone Granitic Creosote Bush Scrub Study Site.

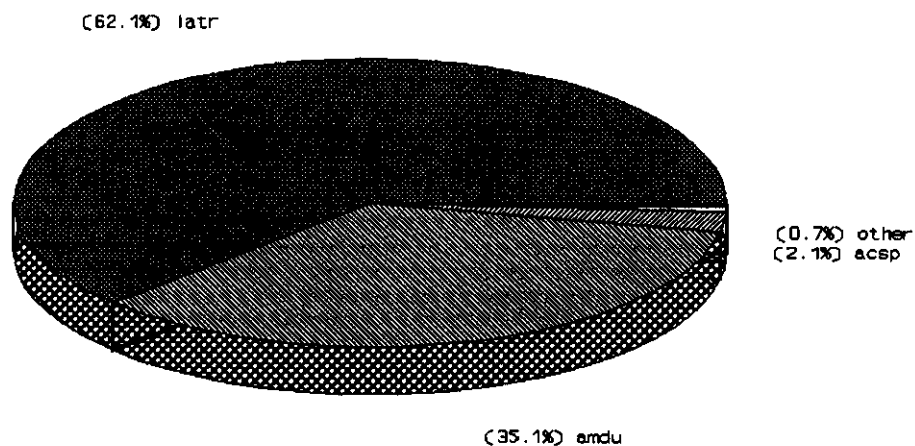


Figure 7. Species Composition for the Goldstone Volcanic Creosote Bush Study Site.

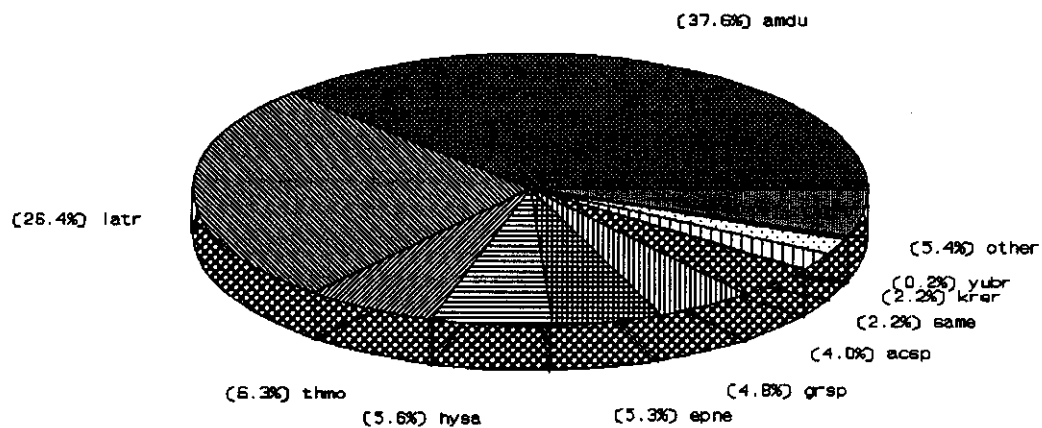


Figure 8. Species Composition for the Goldstone Mixed Creosote Bush Scrub Site.

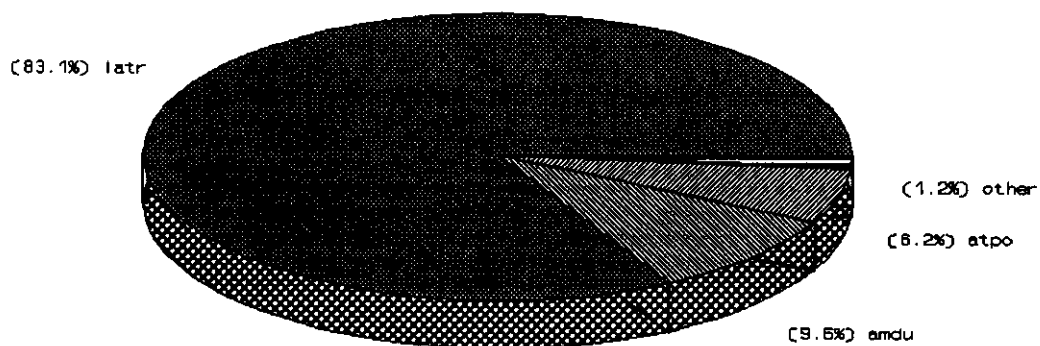


Figure 9. Species Composition for the Bitter Springs Creosote Bush Scrub Site.

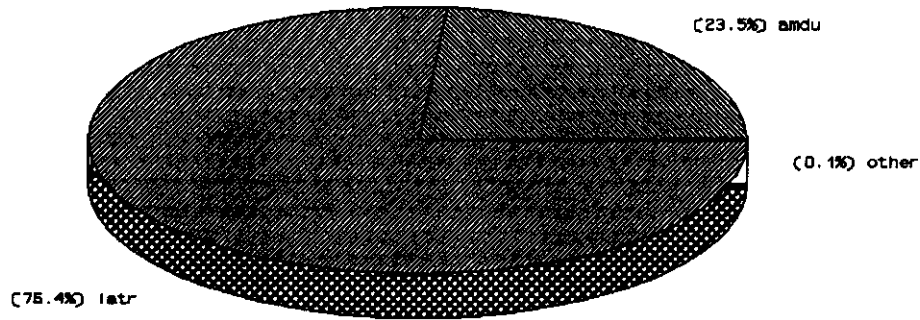


Figure 10. Species Composition for the Soda Mtns. Creosote Bush Scrub Control Study Site.

Saltbush Scrub

Saltbush scrub typically occurs on dry lake margins where soil salinity and low permeability to water prevents the establishment of some desert shrubs (Barbour, 1969 and Lunt, Letey and Clark, 1973). In addition, nocturnal cold air moving out of the mountain canyons toward the lowest point in the basin produces minimum air temperatures below the tolerance range of *Larrea tridentata* (Beatley, 1974a). Soils are moderately alkaline and range from loam to clay loam.

The elevational range for this community is from 500 to 1000 meters. The dominant species is *Atriplex confertifolia* and common shrubs include other species of *Atriplex*, *Artemisia spinescens*, *Krascheninnikovia lanata*, *Ambrosia dumosa*, *Lycium andersonii* and *Hymenoclea salsola*.

This association was represented by the study site GLSBS (Figure 11), situated on the northern margin of Goldstone Lake. A total of 13 perennial species were present in this site, showing a cover value of 10.08 percent. *Atriplex confertifolia* was

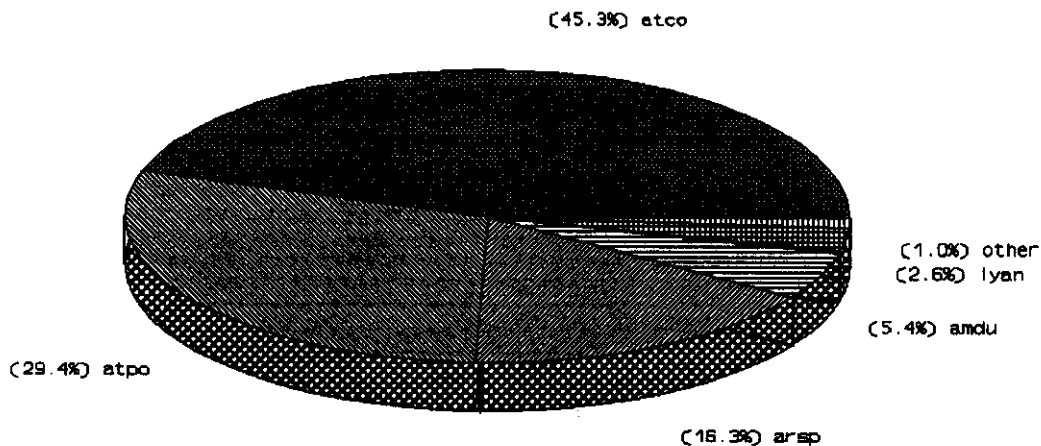


Figure 11. Species Composition for the Goldstone Lake Saltbush Scrub Study Site.

the dominant species with a relative cover of 45.27 percent, followed by *Atriplex*

polycarpa, 29.42 percent, and *Artemisia spinescens*, 16.33 percent.

Desert Wash Scrub

Desert Wash Scrub is composed of a distinctive set of shrubs growing along washes or runnels. The actual species composition of this community varies from wash to wash and may include species of *Ephedra*, *Senna armata*, *Encelia frutescens*, *Hymenoclea salsola*, *Psoralea arborescens*, and *Salazaria mexicana*. *Prunus fasciculata* and

Chilopsis linearis occur at higher elevations. Figure 12 presents the species composition of the Desert Wash Scrub study site, GMWASH, where *Hymenoclea salsola* and *Psoralea arborescens* were the dominant shrubs, showing a relative cover value of 58.29 percent and 39.49 percent respectively. Percent cover in this site was 25.03 percent with a total number of species of 6.

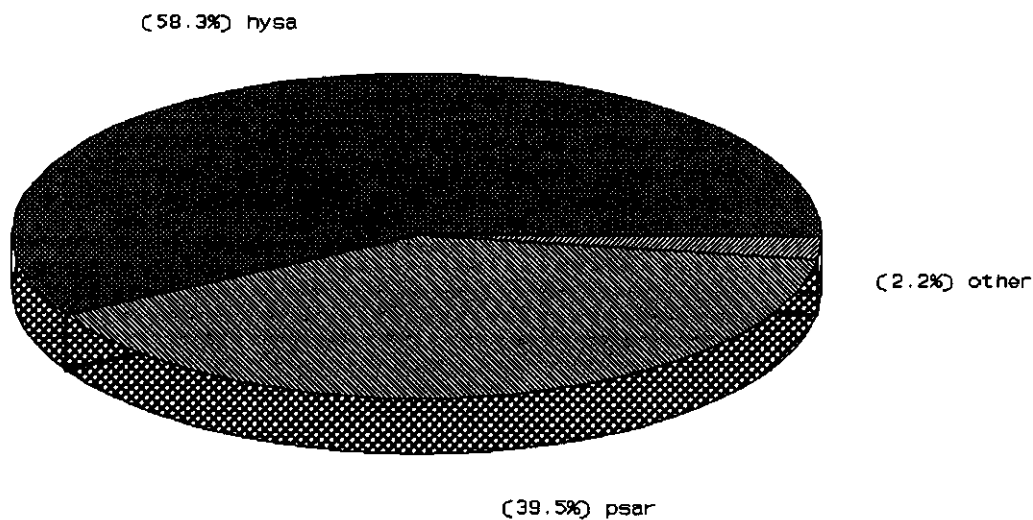


Figure 12. Species Composition for the Desert Wash Scrub Study Site.

Disturbance study

Figures 13 and 14 present the effect of vehicle impact on the perennial vegetation cover and density of two sites, a control site (SMCBSC) and a heavily impacted site (SMCBSD). Both parameters decreased significantly, at the 95 percent confidence level, as a consequence of vehicle impact. The control site showed an average percent vegetation cover of 12.99 percent whereas the average cover on the impacted site was 7.6 percent. Similarly, the average vegetation density in the

control site was higher (101.25 individuals) than the average density in the impacted site (21.37 individuals). These results are consistent with the findings of previous studies on the effects of military training on vegetation parameters (Kryzik, 1984 and Ferrús-García, 1995). As in this study, data collected in 1993 by the author showed that perennial vegetation cover and density significantly decrease as the level of disturbance caused by military vehicles and personnel increases.

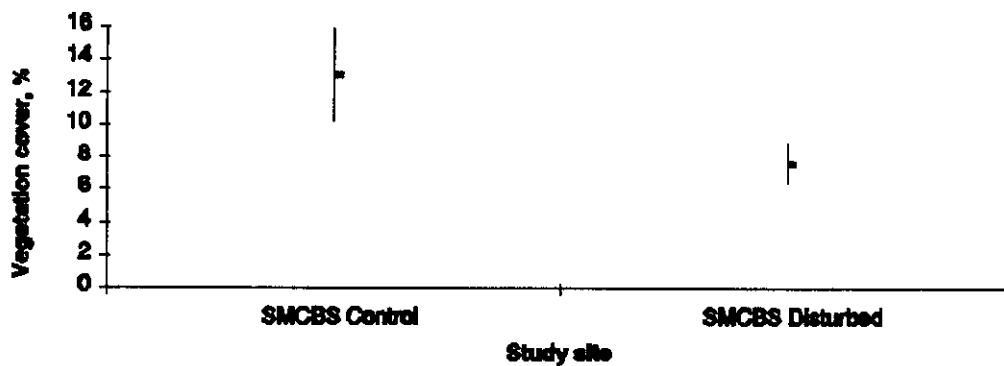


Figure 13. Vegetation Cover at a Control and Disturbed Study Site. Tick indicates mean and bar indicates 95 percent confidence limits.

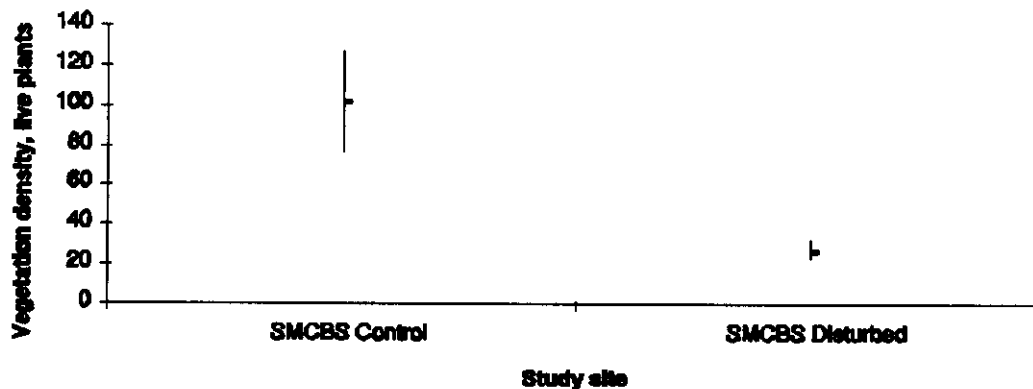


Figure 14. Vegetation Density for an Undisturbed and Disturbed Study Site. Tick indicates mean and bar indicates 95 percent confidence limits.

Herbaceous Vegetation Sampling

The herbaceous vegetation on ten of the study sites was sampled in 1994. Time constraints prevented the survey crew from sampling the site GMCBS. Tables 1 and 2 present percent frequency of occurrence, species richness and standing crop for the study sites surveyed. Results for between-plots and under-plots are presented separately because some herbs always grow beneath shrubs whereas others occupy the bare soil spaces between shrubs. A few herbaceous species indiscriminately occur in both kinds of habitats (Muller, 1953).

Average biomass values ranged from 0 gr/ft² in the three southernmost sites (BSCBS, SMCSBC and SMCBSD) to 0.09 gr/ft² and 0.11 gr/ft² for between- and under-plots on one Goldstone site (GGCBS). Similarly, the number of herbaceous species per site ranged from 0 species in the three southern plots mentioned above to 8 species for between-plots in the site AMBBS and 8 species for under-plots in the Goldstone site GGCBS. These values were quite low but not surprising given the small amount of rain received by the area. Beatley (1974b) in her 13 year study of phenological events in the Mojave Desert

of southern Nevada concluded that one rain of at least 25mm (1 in.) between late September and early December is essential for high germination rates of winter annuals in the spring. In the absence of a heavy autumn rain, late-winter and early-spring rain can result in moderate germination rates as long as the quantity of water delivered by individual rains exceeds 25 mm. Rains of less than 25mm but more than 15mm may result in scattered germination, which is the equivalent of no germination to some of the consumers in desert systems (Beatley, 1969).

According to records from Bicycle Lake Airfield at Fort Irwin, there was no rainfall between September and December 1993 and only occasional rains between January and May 1994, the end of the growing season. Although the total seasonal rainfall was 34.5 mm (1.38 in), the quantity of water delivered by any individual rain did not exceed 8.25 mm (0.33 in), and consequently only a minimal number of winter annuals were triggered to germinate. The most-frequently occurring species at all sites except one was red brome (*Bromus madritensis* ssp. *rubens*) with frequency values ranging from 11 percent for between-plots and 4 percent for under-plots (site GVCBS) to 63 percent and 50 percent for between- and under-plots respectively (GMGCBS). This introduced winter annual which appears to have less restrictive germination requirements and higher seedling survival, has been observed in all growing seasons. Other frequently-occurring species were *Erodium cicutarium* and *Euphorbia albomarginata*, being present in five and four of the sites respectively.

Table 1. Percent Frequency, Species Richness and Standing Crop of Herbaceous Species for Sites Located in the Avawatz Mtns., the Granite Mtns. and Bitter Springs.

Species	AMBBS		AMCBS		GMGCBS		GMWASH		BSCBS	
	B	U	B	U	B	U	B	U	B	U
<i>Amsinckia tessellata</i>	0	0	0	0	0	0	0	0	0	0
<i>Astragalus purshii</i>	2.08	4.17	0	0	0	0	0	0	0	0
<i>Bromus madritensis ssp. rubens</i>	47.9	50.0	21.9	32.3	62.5	50.0	50.0	45.8	0	0
<i>Cryptantha pterocarya</i>	0	0	0	0	0	0	0	0	0	0
<i>Eriophyllum wallacei</i>	2.08	2.08	0	0	0	0	0	0	0	0
<i>Eriogonum deflexum</i>	4.17	6.25	0	0	0	0	0	0	0	0
<i>Eriogonum inflatum</i>	4.17	0	1.04	6.25	0	0	0	0	0	0
<i>Eriogonum nidularium</i>	4.17	0	0	0	0	0	0	0	0	0
<i>Eriogonum pusillum</i>	0	0	0	0	0	0	0	0	0	0
<i>Eriogonum spp.</i>	0	0	1.04	3.13	1.04	0	0	0	0	0
<i>Erodium cicutarium</i>	4.17	0	8.33	2.08	7.29	6.25	0	0	0	0
<i>Euphorbia albomarginata</i>	14.6	6.25	9.38	3.23	3.13	2.08	16.7	4.17	0	0
<i>Mimulus bigelovii</i>	0	0	0	0	0	0	4.17	4.17	0	0
<i>Phacelia cf. vallis-mortae</i>	0	2.08	0	0	0	0	0	0	0	0
<i>Salvia columbariae</i>	0	0	0	0	0	0	0	0	0	0
<i>Schismus barbatus</i>	0	0	0	0	0	0	0	0	0	0
<i>Vulpia octoflora</i>	0	0	0	0	0	0	0	0	0	0
Species Richness	8	6	5	5	4	3	3	3	0	0
Biomass (gr/ft ²)	0.03	0.03	0.02	0.01	0.03	0.03	0.05	0.01	0	0

NOTE: B = Between-plots; U = Under-plots

Table 2. Percent Frequency, Species Richness and Standing Crop of Herbaceous Species for Sites Located in Goldstone and the Soda Mtns.

Species	GGCBS		GVCBS		GLSBS		SMCBSC		SMCBSD	
	B	U	B	U	B	U	B	U	B	U
<i>Amsinckia tessellata</i>	0.93	0	0	0	0	0	0	0	0	0
<i>Astragalus purshii</i>	0	0	0	0	0	0	0	0	0	0
<i>Bromus madritensis ssp. rubens</i>	16.7	44.4	11.11	4.167	0	0	0	0	0	0
<i>Cryptantha pterocarya</i>	0	0.93	0	0	0	0	0	0	0	0
<i>Eriophyllum wallacei</i>	0	0	0	0	0	0	0	0	0	0
<i>Eriogonum deflexum</i>	0	0	0	0	0	0	0	0	0	0
<i>Eriogonum inflatum</i>	0	0	0	0	0	0	0	0	0	0
<i>Eriogonum nidularium</i>	0	0.93	0	0	0	0	0	0	0	0
<i>Eriogonum pusillum</i>	5.56	3.7	0	0	0	0	0	0	0	0
<i>Eriogonum spp.</i>	0	0	0	0	0	0	0	0	0	0
<i>Erodium cicutarium</i>	51.9	54.6	0	0	0	0	0	0	0	0
<i>Euphorbia albomarginata</i>	0	0	0	0	2.08	0	0	0	0	0
<i>Mimulus bigelovii</i>	0	0	0	0	0	0	4.17	4.17	0	0
<i>Phacelia cf. vallis-mortae</i>	0	0	0	0	0	0	0	0	0	0
<i>Salvia columbariae</i>	0	0.93	0	0	0	0	0	0	0	0
<i>Schismus barbatus</i>	50.9	40.7	0	0	0	0	0	0	0	0
<i>Vulpia octoflora</i>	17.6	13	0	0	0	0	0	0	0	0
Species Richness	6	8	1	1	1	0	0	0	0	0
Biomass (gr/ft ²)	0.09	0.11	0.002	0.003	0.001	0	0	0	0	0

NOTE: B = Between-plots; U = Under-plots

Validity of Sampling Design

The last objective of this study was to determine the validity of the sampling design. This was accomplished in two ways. First, analysis of variance (ANOVA) was performed on the cover values for each study site; second, species: area curves were created for each site.

ANOVA Analysis on Cover

ANOVA compares the variation in cover values within samples (within transects A and B on each site) to the variation in cover values between samples (between transects A and B for the same study site). If the within-sample variation is significantly larger than the between-sample variation, then it can be concluded that the cover values for transects A and B on a given site are the same and that such a site has been sampled adequately. On the other hand, if the within-transect variation is significantly smaller than the variation between transects, then it can be concluded that the percent cover for transects A and B is significantly different and that more transects are needed to obtain an adequate cover value for that particular site (Johnson, 1988).

The analysis of variance was performed on all study sites except the Desert Wash site, where the small size of the community limited the number of sampling quadrats and only two were established. ANOVA results showed that all study sites analyzed had been surveyed adequately with the exception of the Saltbush Scrub site on the margins of Goldstone Lake (ANOVA tables are presented in Appendix C). There was a significant difference between the cover for transect A on this site (14.2 percent) and that of transect B (6.0 percent), probably due to a difference in water availability. Although both transects had

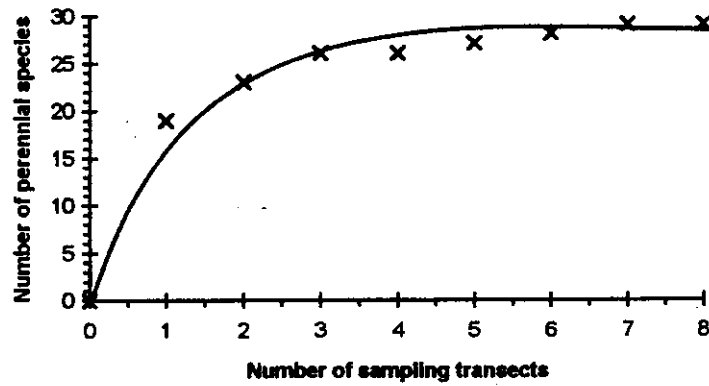
similar slope and soil, transect A was close to slopes from which it would receive water runoff. Transect B was quite far from slopes and any runoff from these slopes probably percolates into the ground over an area distant from it. A small wash between the two transects apparently separates the two sites hydrologically. This influence on hydrology and vegetation parameters has also been reported by Schemke (pers. comm.) for *Linanthus parryae* sites and associated vegetation.

Species: Area Curves

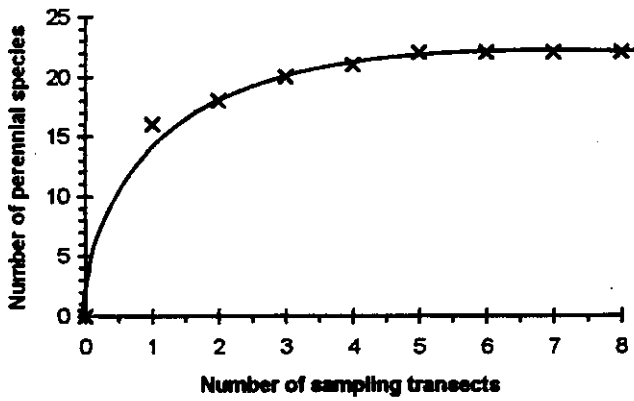
Species: area curves are used to determine whether the number of quadrats sampled is sufficient to obtain a significant number of the perennial species within a community. The number of perennial species accumulated in the sampling is plotted on the y axis/ordinate versus the number of quadrats on the x axis/abscissa. The resulting curve rises sharply at first and then tends to level off as fewer species are added with increased sampling. The number of quadrats is determined to be adequate when further sampling only results in a flattening of the species: area curve (Oosting, 1956).

Figure 13 presents the number of quadrats needed to adequately sample the perennial species richness of each study site. Sampling intensity was adequate for all sites. Most of them required 2 or 3 quadrats and only one site, GGCBs, showed an important increase in the number of new species counted after eight quadrats. Nevertheless, eight quadrats were still sufficient because the species appearing after the third quadrat contributed less than 1 percent to the overall cover of the site and had little or no defining power of the community.

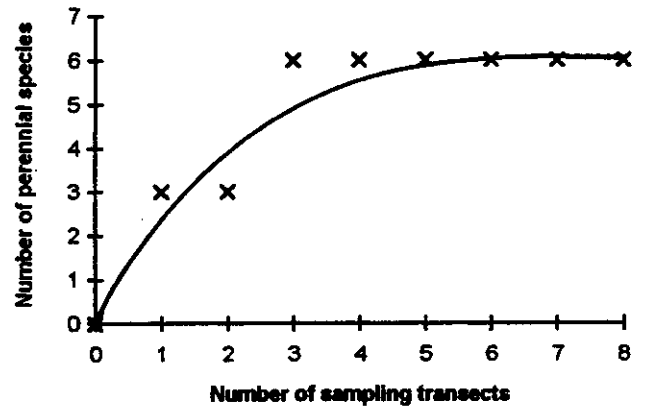
A. Avawatz Blackbush Scrub Study Site



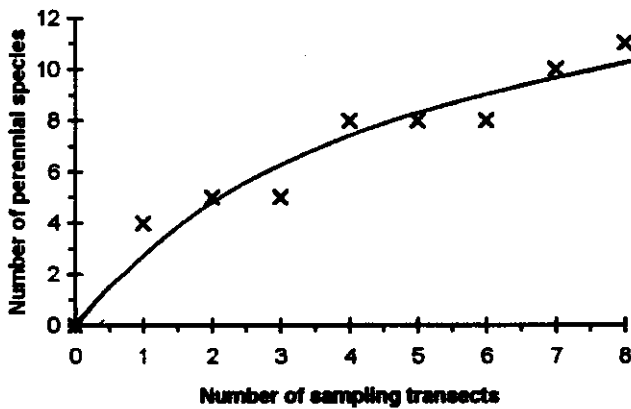
B. Avawatz Mnst. Creosote Bush Scrub Study Site



C. Bitter Springs Creosote Bush Scrub Site



D. Goldstone Granitic Creosote Bush Scrub Site



E. Goldstone Mixed Creosote Bush Scrub Site

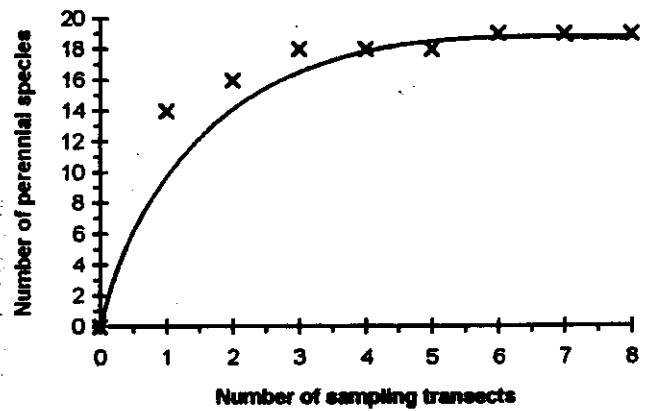
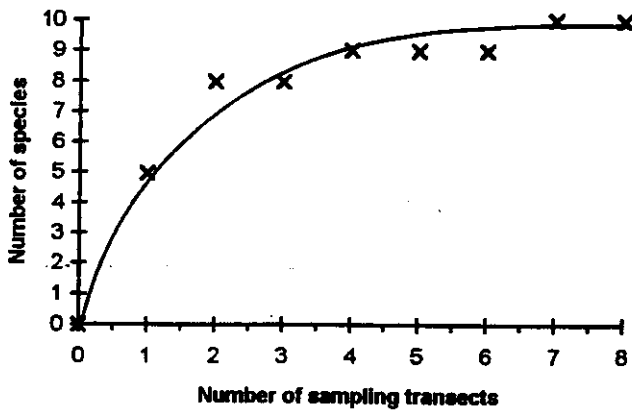
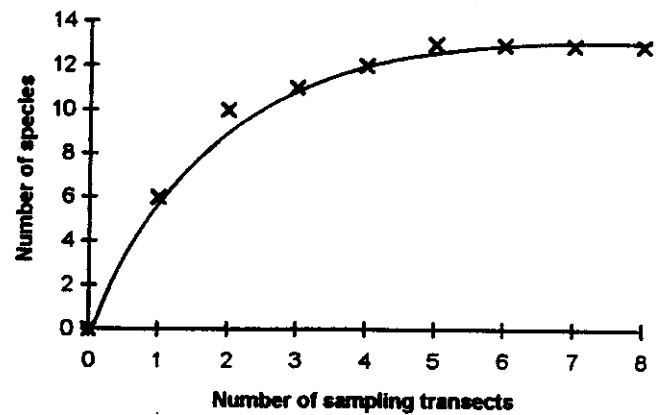


Figure 15. Species:area Curves for All Study Sites.

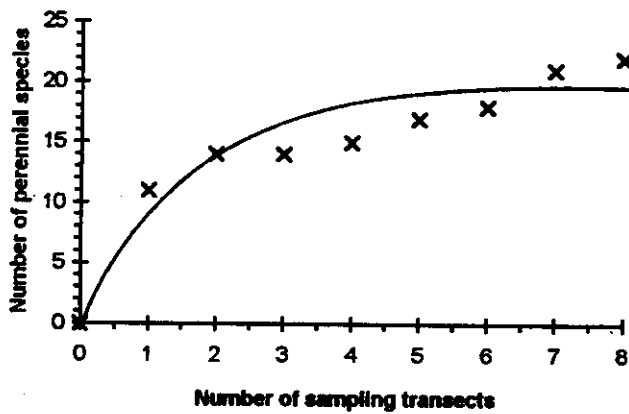
F. Goldstone Volcanic Creosote Bush Scrub Site



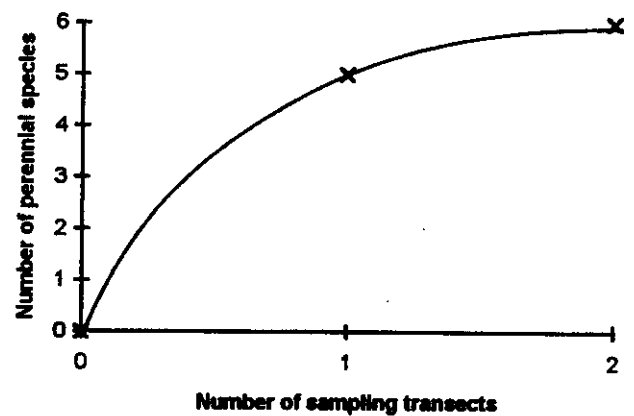
G. Goldstone Lake Saltbush Scrub Study Site



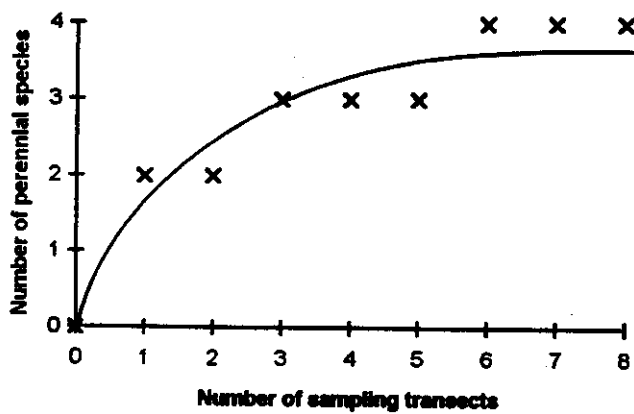
H. Granite Mnts. Granitic Creosote Bush Scrub Site



I. Granite Mnts. Desert Wash Scrub Site



J. Soda Mnts. Creosote Bush Scrub Control Site



K. Soda Mnts. Creosote Bush Scrub Disturbed Site

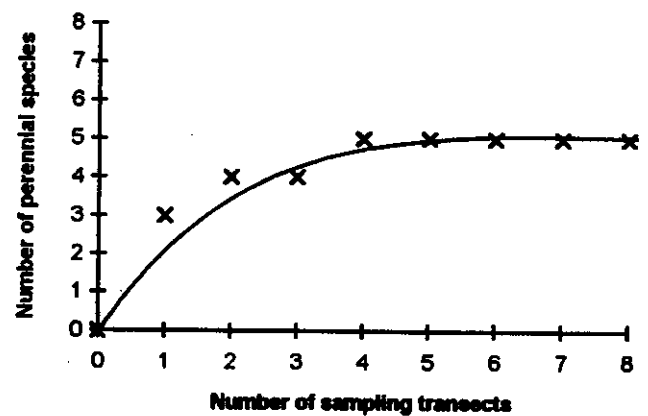


Figure 15. Species:area Curves for All Study Sites (cont.).

PART II

**REPORT ON PRELIMINARY FIELD WORK
FOR VEGETATION MAP**

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and
Barry A. Prigge**

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Description of Work

The UCLA research team agreed to conduct preliminary field work leading to mapping of vegetation at the Fort Irwin/Goldstone Military Reservation and National Training Center (NTC), north of Barstow, California. Fort Irwin/Goldstone includes 267,800 hectares (2,678 km²) in the central Mojave Desert. The principal intent of the current project, as defined by the chief ecologist at Fort Irwin, was to establish protocol for vegetation sampling. The suggested guidelines would then be consulted and hopefully adopted for the next stage, a full mapping project, which certainly will require at least two full years to complete. Guidelines would set standards on how much vegetation sampling would be required to achieve an accurate representation of current plant communities on Fort Irwin/Goldstone. The adopted protocol would dictate the types of professionals and time commitments needed to complete the mapping project at a level of sophistication acceptable to the U.S. Army.

Obvious concerns about mapping such a large desert property are that:

- 1) Users of the vegetation map must be able to ground truth plant communities and variants by using a small set of indicator species;
- 2) Variants in plant communities, if mapped, must be defined by statistical parameters that are testable and reproducible;
- 3) Cost of generating the level of sophistication and accuracy on the initial map are reasonable relative to benefits obtained by future users.

General Description of Fort Irwin/Goldstone Landforms

The Fort Irwin/Goldstone property consists primarily of low elevations, ranging from 290 m on the northeastern corner of the Leach Lake Gunnery Range to 1865 m on the northeastern corner of NTC in the Avawatz Mountains. Less than 1 percent of the total reservation lies above 1300 m, principally in the Avawatz, Tiefert, and Granite Mountains. The 1300-m contour is significant because that coincides roughly with the upper elevational limit of *Larrea tridentata*, creosote bush, which is ubiquitous in the lowland Mojave Desert.

The Fort Irwin/Goldstone property is characterized by the more typical landforms of the Mojave Desert, including:

- 1) Widely separated and rugged granitic mountains, hills, and outcrops of rounded boulders produced from joint blocks by granular disintegration;
- 2) Widely separated volcanic outcrops;
- 3) Sloping pediments and alluvial fans with washes;
- 4) Plains with washes of various widths;
- 5) Flat playa lake floors;
- 6) Very local and weakly defined sand sheets;
- 7) Isolated springs.

Lower bajadas of alluvial fans and plains constitute greater than 60 percent of total land, and within valleys eight major and several very small playa lakes comprise approximately 1 percent of the total.

Flora of Fort Irwin/Goldstone

A floristic survey on sample landforms of Fort Irwin/Goldstone was conducted during spring, 1993, which was a highly

productive season for plant species, and the research team determined that at least 450 species definitely have been collected on or very close to the property (Gibson, Prigge, and Niessen, 1994). The flora contains as many species as was previously estimated for the entire Central Mojave Region (Rowlands, Johnson, Ritter, and Endo, 1982) and for native plants appears to lack only species that either have extremely narrow ranges in the Mojave Desert or require special substrates that either are not found or are of insignificant areal extent on the Reservation.

The 1993 survey was based to a large degree on collections taken in the vicinity of the 200 100-m transects established for the Land Condition/Trend Analysis (LCTA) but also included collecting trips to montane, seep and spring, and special soil habitats. Gibson et al. (1994) tentatively recognized nine plant communities occurring on and around Fort Irwin/Goldstone desert landforms along with specialized vegetation at seeps and springs (Appendix D). The majority of the Reservation, typified by alluvial fans and plains, is dominated by some variant of creosote bush scrub. A number of plant species are known only from a single population at the highest elevation site in the Avawatz Mountains, where juniper woodland and small patches of limestone were discovered. Typical creosote bush scrub can be observed in all sectors of Fort Irwin/Goldstone and was crudely estimated to constitute greater than 95 percent of the property (Gibson et al., 1994). Nearly all mildly and highly disturbed areas used for military maneuvers have some variant of creosote bush scrub. No attempts were made to quantify any of the variants, and quantitative descriptions of the vegetation were being sampled along the LCTA transects by a different research team supported by the Directorate of Public

Works, Fort Irwin.

Goals for Mapping Vegetation at Fort Irwin/Goldstone

Before proceeding toward a vegetation map, those who contract the project need to itemize the purposes for having the map. A map of Fort Irwin/Goldstone should be designed to show the dominant plant community at every location on the Reservation. Future studies can delineate the impacts on these communities due to military land use. Using this as the overall development plan, this preliminary phase of the mapping project has four primary goals:

- 1) Determine the amount of vegetative sampling for dominance and cover that would be required to map plant communities and their variants on the Reservation. Vegetation sampling is the gathering of data that will permit sites to be classified into definable plant communities. A classification of plant communities often includes at least some qualitative or quantitative measurement of dominance, density, or cover and may also include biomass.
- 2) Determine suitable methods of analyzing quantitative transect data. The wealth of data from a large vegetation sampling study can quickly become a confusing mass of information. Computerized algorithms are required to quickly analyze the data and to classify the transects into plant communities. Several methods need to be reviewed to determine which provide the most useful results.
- 3) Identify a small set of perennial species that can be used as a reliable indicator of each plant community and its variants on the Reservation. Based on the results of the community classification, a

list of diagnostic species for each community will be assembled to provide a means of identifying plant communities in the field. Communities that can be properly identified will not have to be sampled.

4) Set standards for site selection and vegetative sampling for each plant community or common variant that has not been studied on the Reservation.

Databases for Vegetation Sampling

On November 18 and 19, 1994, the UCLA research team conducted test sampling on the Goldstone portion of the Reservation to evaluate time and the intensity of sampling required to obtain reliable density and cover data from a field survey. These preliminary tests were done on Goldstone property at ten sites (Appendix F) representing several of the common scrublands on the Reservation: creosote bush scrub on lower bajadas, creosote bush on rocky slopes, saltbush scrub around a playa, saltbush scrub on a disturbed site, mixed desert scrub vegetation on bouldery granitic slopes, and shadscale-creosote bush scrub on a volcanic mesa. Density sampling was made with a strip quadrat (belt transect) that measured 100 X 5 m, and cover was measured separately along two parallel (5 m apart) 100-m line intercepts at each site. We were also interested in assessing the problems associated with density data, e.g., individual plants versus clones. Sampling times, of course, are highly correlated with vegetation density; principal interest here was to obtain broad generalizations about sampling times required and not any statistically valid evaluations.

There are more than 200 sites on Fort Irwin/Goldstone that have been sampled quantitatively for the Land

Condition/Trend Analysis (LCTA) by a research team supervised by the Directorate of Public Works at Fort Irwin. In 1992 and 1993 these sites were sampled by that research team for perennial plant cover along each 100-m transect and for perennial plant density within a 100 X 6-m strip quadrat. Goal of that long-term survey has been to document changes in perennial vegetation on undisturbed versus disturbed samples of habitats, i.e., to monitor effects of military maneuvers on the desert. Data from these transect studies were given to this mapping project for developing the preliminary classification of vegetation on the Reservation. Of these only 103 (numbers 1 through 200 in Appendix G) had reliable values for cover. In 1990-1992, the point-intercept method was utilized to measure cover. Mueller-Dombois and Ellenberg (1974) recommended 200 sampling points to obtain an accurate value for a homogeneous plant cover; more variable systems might require a higher number. In the LCTA methodology, only 100 points were sampled per transect and cover values derived from those measurements were not reliable. Some LCTA sites are obviously Creosote Bush Scrub, but the point-intercept method failed to measure any *Larrea tridentata* or *Ambrosia dumosa*. Such transects illustrate the extreme undersampling of cover in the LCTA data and raise questions about the accuracy of the cover estimates from the LCTA transects sampled before 1993. See Appendix E for locations of all mapping transects.

Three sources of aerial documentation for the Reservation were made available by Dr. Christopher Lee, California State University, Dominguez Hills. These included 1) a computer-displayed French satellite imagery series, 2) a nearly complete, high-elevation aerial photographic series, and 3) a Fall, 1994

video recording from a helicopter reconnaissance of a low-elevation roundtrip from McLean Dry Lake to Leach Dry Lake on Fort Irwin. Even with maximal computer enlargement of images, no useful mapping data for plant communities could be obtained from satellite imagery, so that database was not used. Individual large shrubs could be detected from the aerial photographs, but species identity of each could not be made with certainty, so those photographs were not useful for the current mapping project. To be useful for accurate vegetation mapping, low elevation aerial photographs printed at a scale of 1 cm:100 m would have to be obtained. The video recording taken by Dr. Lee from the helicopter window showed that some version of this method can be used to map any portion of the base. Plant communities can be recognized from 1000-3000 m elevation and cover can be estimated, but camera angle will have to be controlled and some ground truthing will be required. However, for the preliminary report, no quantitative use of the video recording was attempted.

Density and Cover for Goldstone Transects

Density

Sampling a 100 X 5 m strip quadrat required 80 minutes (60-90 minutes). This measure for species densities was not only very time consuming but also had the inherent problem that the observer must be able to clearly distinguish individual plants. Several of the species of the Mojave Desert are clonal, especially creosote bush (*Larrea tridentata*). Unfortunately, density results can be grossly skewed to higher or lower densities depending on whether one treats a clone as one individual plant or several.

Although guidelines can be established to promote consistency in determining clones, there will remain ample room for error or difference of opinion, especially with different persons sampling the vegetation.

Cover

For fairly typical vegetation of Fort Irwin with total cover values ranging from 0.3-39.4 percent (Appendix G), the time required for a team of two to sample each line intercept on average was 16 minutes (12-20 minutes), excluding rugged granitic outcrops, which required more than double the time. Hillsides and mountain slopes were best sampled along the contour, which then included a variety of microhabitats around the landform. Sampling along a contour was preferred for gently sloping pediments and alluvial fans, but sampling in any direction ran a risk of passing through runnels or minor washes, which had different representative shrubs. Substantial differences in cover values were obtained for paired 100-m transects at a site.

As just noted, in deserts differences in local topography often result in major changes in plant density or species composition, due to drainage patterns of rainwater and infiltration and water storage properties of the soils. To reduce error one must sample enough of a habitat to a level of confidence, and a simple way to evaluate sampling adequacy is to ascertain the point beyond which changes in the average become insignificant. Therefore, if cover values are to be used for mapping, investigators need to determine relative confidence of each reference point (Daubenmire, 1968).

A type of diminishing return analysis was done on the data from one site south of Goldstone Dry Lake, where distances of bare ground between plants was

recorded. The line transect was divided into 15-m segments and computerized simulations were done that randomly selected segments with replacement. A total of 90 simulations were performed in which 200 segments were selected. Total cover was calculated after each 15-m segment based on the cumulative distance of the segments. Total cover versus distance sampled were plotted to determine the point of diminishing return for 1 percent and 2 percent difference in cover, i.e., the first point at which the difference between total cover of the simulation and the cover obtained from the 200-m transect (10.2 percent) was less than 1.0 percent or 2.0 percent for the remainder of the simulation. The mean point of diminishing return for the 90 simulations indicated that 900 meters of transects were required for a difference of 1 percent (or 10 percent error for this site) and 400 meters for 2 percent (or 20 percent error for this site). Again, there are separate problems if within 400 meters the line transect passes through major water drainages, or the landform is very steep so that soil water gradients change radically, or the habitat is very limited in size or uses a very special substrate. Prior to setting up a line transect, the site should be surveyed to insure that the transect is within a homogeneous stand of vegetation and substrate. Habitat homogeneity is determined based upon perennial species composition, spacing, and height of the plant biomass and soil characteristics such as texture, nature of parent material, and slope.

Sampling intensity in extremely sparse vegetation or highly disturbed sites would require more or longer transects to obtain reliable data. Sites with higher, more uniformly spaced cover could require less sampling.

The point-intercept method, which can

generate cover data, was also performed along one of the ten transects. The UCLA research team learned from that one sample that the point intercept method could not be seriously evaluated because of the following reasons:

- 1) To minimize subjectivity, a line has to be strung;
- 2) Sampling every meter is not adequate sampling;
- 3) Once a line is strung, one might as well gather the line-intercept data, which are more reliable;
- 4) If one increased the number of sampling points, again one would be better off doing the line intercept.

The point intercept method, when done by walking over a site, is undoubtedly a very quick technique to obtain cover data, but it is also very vulnerable to subjectively aiming for a plant or bare ground depending on personal bias. Stringing line and sampling at predetermined intervals can eliminate or at least minimize subjectivity, but then it increases the time to sample a site. We do not deem point intercept method to be nearly as good as the line intercept method.

The greater time required for density sampling over cover sampling was due to 1) time required to lay out a grid, and 2) more plants were sampled. The former was definitely a negative attribute of density sampling, but the latter was a positive attribute. Another possible deficiency of density measures is that data obtained can be very misleading, especially where small plants may have a high density but contribute little to the total biomass of the site.

The line intercept appeared to have several advantages over the density

method in evaluating desert scrub vegetation:

- 1) Cover data can be gathered faster using the line intercept method than density data can be gathered using strip quadrats.
- 2) Cover data is not vulnerable to errors in discriminating between individuals and clones.
- 3) Biomass is generally more closely correlated with cover data than it is to density data, so that if cover is mapped, future workers may be able to extrapolate biomass numbers from the map, using cover:biomass regressions.

There are other field methods of obtaining cover and density values but in general they would be more laborious and time consuming than the methods already discussed. One possible exception for large-scale cover mapping may be video camera footage from low-flying helicopter used to calculate shrub cover on selected frames. For a video project, safeguards would be required to control camera angle, locate accurately coordinates for sampled frames, and have high enough quality to resolve identities of dominant and common perennial. From video studied at CSU Dominguez Hills, certainly *Larrea tridentata* was extremely easy to identify from a helicopter, but identifying grayish, drought-deciduous shrubs offered major challenges.

Other Possible Measures for Mapping

Frequency techniques were not evaluated because of the four parameters (biomass, cover, density, and frequency), it is probably the least important in the classification of vegetation into communities. Although the only way to determine dispersion patterns, frequency

values are very sensitive to quadrat size and would require sampling at different quadrat sizes, a time consuming method.

Biomass of each species would undoubtedly be an ideal parameter to have for mapping but would be destructive in that some plants would have to be collected, dried, and weighed. Vegetation maps typically do not indicate biomass values.

Plant Communities and Indicator Species

Sampling data from the LCTA sites were present from two sources, 1) 1993 data of occurrence, cover, and density along the transects and 2) the species list for each plot done for the 1993 floristic survey of Gibson et al. (1994).

Many of the computerized methods for analyzing vegetative data and classifying transects into plant communities or associations were reviewed. Generally these methods can be placed into two classes: divisive versus agglomerative methods. The divisive methods subdivide an entire data set into successively smaller units. Those that were reviewed are TWINSpan (Hill, 1979b), DECORANA (Hill, 1979a), and principal component analysis (Sneath and Sokal, 1973; Rohlf, 1988). The agglomerate methods combine the most similar units to form groups or clusters proceeding until all transects are members of one group. For this UPGMA, WPGMA, complete linkage, flexible, and single linkage methods of cluster analysis were reviewed (Sneath and Sokal, 1973; Rohlf, 1988). For cluster analysis we also had to consider the various methods of calculating similarity and dissimilarity.

Initially, to evaluate these methods, the 1993 floristic survey lists were used to generate a presence/absence data matrix of transects and species but yielded

minimally useful results because it included annual species and uncommon or rare species, which had little or no defining power of the community. A data matrix of only perennial species yielded more satisfactory results but still lacked the desired resolving power.

Using the LCTA data density was also analyzed, but like the presence/absence data failed to yield satisfactory results.

Finally, cover data was used to analyze these methods. The cover data used is from the 1993 LCTA transect survey, which calculated cover by measuring shrub diameters within 103 strip quadrats 100 X 6-m (Ferrús-García, unpublished) and the ten 200-m transects from the current study. Cover data from LCTA transects prior to 1993 were estimated by the point-intercept method based on 100 points sampled at 1-m intervals along a 100-m line (Shaw, 1990). These earlier data were not considered reliable because sampling intensity was low, given that minimum number of sampling points for homogeneous vegetation is 300-500 points (Evans and Love, 1957).

Satisfactory results were obtained from TWINSpan, DECORANA, and UPGMA cluster analysis. These are discussed below. Results from principal components analysis were not nearly as useful as DECORANA and are not discussed.

TWINSpan

TWINSpan (Hill, 1979a; Hill et al., 1975) is a divisive method that successively divides the data set into two groups based on an ordination technique using reciprocal averaging. At each division the characteristic or indicator species are determined as those more representative of each division. From this analysis results a transect-by-species matrix, in which species are grouped based on their

fidelity with a community. The result is similar to the Braun-Blanquet method of community classification (Mueller-Dombois and Ellenberg, 1974).

Preliminary results for relative cover data with weighting of the more dominant species are presented in Figure 1. Transect numbers are listed across the top of the data matrix; species are listed at the left by a four letter code (codes for species are listed in Appendix I). The classification of samples into plant communities are indicated above the transects across the top where GS = galleta grass sand fields, Dst = disturbed, CSS = cheesebush-senna scrub, S = shadscale, CBS = creosote bush scrub, M = mixed desert scrub, SBS = saltbush scrub, and AS = allscale scrub. Values indicate a scale of abundance, with absence of a species represented by a period, high cover species = 5. The rows of zeros and ones below the matrix indicate the groupings of transects in each iteration of the analysis. Thus, in the first iteration the allscale scrub transects (1's) are separated from the rest of the transects (0's). In the subsequent iterations, each group of the previous iterations is subdivided into two groups unless the previous group size is too small (<3). Species at the top are more closely correlated with communities on the left side to the figure, and species at the bottom are more closely correlated with communities on the right side of the figure. Two factors tend to obscure the patterns in this species-plant community matrix: 1) species with broad ecological amplitude that occur in most of the communities, and 2) the sporadic occurrence of some species in several communities.

TWINSpan results suggest that the creosote bush scrub community can be split into two separate communities. Transects A8, 2, 3, 5, 18, 27, 38, 39,

47, 130, 199, A1, A9, and 166 of the creosote bush scrub on this figure are, in general, the higher elevation sites that have higher shrub diversity.

Such results are not entirely clear, because several species have wide distributions, e.g., creosote bush (*Larrea tridentata*) and burrobush (*Ambrosia dumosa*). Some other species occasionally appear in several different communities and thus create unwanted noise in the matrix. Nevertheless, there are nine sensible groupings. Working from left to right in Figure 1, the following groups are recognizable.

1) Galleta Grass Sand Fields. These sites (Transects 60, 68, 141) are dominated by galleta grass (*Pleuraphis rigida*) and sometimes also by *Ambrosia dumosa*, croton (*Croton californicus* var. *mojavensis*), and desert-tea (*Ephedra californica*). Other perennial species are also present (Appendix H), but within the strip quadrats these are too sparse to be included. Transects 56, 66, 70, 75, and 140 are sites that are classified as creosote bush scrub have significant cover of *Pleuraphis rigida*.

2) Disturbed. This group is not possible to classify based on the plant cover of the strip quadrats because its vegetation is too sparse and disturbed. One site (Transect 53) is located in the middle of a large, well-scoured wash and should be called barren. Another (Transect 145) is in the Cantonment area adjacent to an intersection of two roads and likely a ruderal area that is frequently disturbed. Transects 161 and 167 are disturbed sites with only 3.1 percent and 2.2 percent cover, respectively.

3) Cheesebush-Senna Scrub. This group of six sites (Transects 14, 16, 109, 123, 151, 196) represents a plant community that appears in washes or on alluvial

slopes having many small washes or periodic sheet washing. Cheesebush *Hymenoclea salsola*, armed senna (*Senna armata*), *Larrea tridentata*, and *Ambrosia dumosa* are the dominant perennial.

4) Creosote Bush Scrub. A large group of 73 transects represents typical creosote bush scrub dominated by *Larrea tridentata*, *Ambrosia dumosa*, or generally by both. Other common perennial associates that were recorded in the strip quadrat were *Hymenoclea salsola*, Pima rhatany (*Krameria erecta*), wishbone herb (*Mirabilis bigelovii*), and Nevada-tea (*Ephedra nevadensis*). Moderately important on some sites were turpentine-broom (*Thamnosma montana*), needlegrass (*Achnatherum speciosum*), Mojave indigo bush (*Psoralea arborescens*), dotted dalea (*P. polydenius*), box thorn (*Lycium andersonii*), winter fat (*Krascheninnikovia lanata*), hop-sage (*Grayia spinosa*), brittlebush (*Encelia farinosa*), desert straw (*Stephanomeria pauciflora*), and desert aster (*Xylorhiza tortifolia*). The last 13 transects of this group have a higher species diversity of shrubs, especially with *Lycium andersonii*, *Grayia spinosa*, Mojave cotton-thorn (*Tetradymia stenolepis*), and goldenhead (*Acamptopappus sphaerocephalus*); these occur in the upper elevational range of *Larrea tridentata* and represent a transition zone to the next higher plant community. The TWINSpan analysis separates these sites out from the rest of creosote bush scrub, but a practical dividing line is difficult to make at this time.

5) Shadscale-Creosote Bush Scrub. These sites (Transects 41, 48, 50, 171, A3) are generally dominated by shadscale (*Atriplex confertifolia*) and to a lesser extent by *Larrea tridentata*. Other species abundant enough to be sampled were California buckwheat (*Eriogonum fasciculatum* ssp. *polifolium*), *Achnatherum speciosum*, *Lycium*

andersonii, *Krascheninnikovia lanata*, *Ambrosia dumosa*, *Thamnosma montana*, *Tetradymia stenolepis*, *Grayia spinosa*, and *Ephedra nevadensis*. This vegetation occurs on rocky or bouldery volcanic slopes and ridges, where soils appear to be sandy loams or loamy sands.

6) Blackbush-Creosote Bush Scrub. Fifteen sites (Transects 6, 7, 9, 43, 51, 54, 64, 97, 104, 106, 121, 154, 173, 183, 185) represent a transition zone between creosote bush scrub and blackbush scrub. Such habitats occur on upper slopes of alluvial fans. Whereas *Larrea tridentata* and *Ambrosia dumosa* dominate or nearly dominate this plant community, shrub diversity is higher than that of typical creosote bush scrub. Blackbush (*Coleogyne ramosissima*) was present on five of the sites and reached a moderate dominance on four (Transects 9, 104, 106, 164). Joshua tree (*Yucca brevifolia*) occurred on four of the sites (Transects 51, 54, 97, 164) but not in significant numbers to warrant classification as Joshua tree woodland. Other common shrubs on the transects are bladder sage (*Salazaria mexicana*), *Eriogonum fasciculatum* ssp. *polifolium*, *Encelia actonii*, goldenbush (*Ericameria cooperi*), *Lycium andersonii*, *Ephedra nevadensis*, *Hymenoclea salsola*, and *Krameria erecta*. Of these samples, Transect 104 is the closest to being classified as blackbush scrub, a plant community that occurs at higher elevations in the Granite Mountains and Avawatz Mountains.

7) Mixed Desert Scrub. Group 7 represents rocky to bouldery mountain slopes, which to date have been very poorly sampled. Only Transects A6 and A7 are from this habitat. This community is a diverse assemblage of shrubs with low density. Common species are *Ericameria cuneata*, *E. cooperi*, needle-leaved rabbitbrush (*Chrysothamnus*

teretifolius), *Salazaria mexicana*, *Brickellia arguta*, *Eriogonum fasciculatum* ssp. *polifolium*, *Achnatherum speciosum*, and *Poa secunda*.

8) Saltbush Scrub. These sites (Transects 1, 42, 44, A4) are dominated by *Atriplex confertifolia* or also by allscale (*A. polycarpa*), fourwing saltbush (*A. canescens* ssp. *canescens*), *Krascheninnikovia lanata*, bud sagebrush (*Artemisia spinescens*), *Lycium andersonii*, *Hymenoclea salsola*, and *Ambrosia dumosa*. This community occurs on relatively fine (loamy sand to sand loam), slightly saline soils. So few transects were used that more sampling may reveal one or more variants. Transect A4 is somewhat anomalous and is a disturbed site dominated by *Atriplex confertifolia*; prior to disturbance the vegetation probably was more like the surrounding areas, which are shadscale-creosote bush scrub. Transect 1 is somewhat different from Transects 42 and 44.

9) Allscale Scrub. Only two sites (Transects 144, A10) are dominated by *Atriplex polycarpa*. Transect 144 is a slope near Bitter Spring where vegetation is very sparse and soils are slightly saline. The dominant cover consists of *Atriplex confertifolia* and bush seepweed (*Suaeda moquinii*), but also scattered there are *Larrea tridentata*, *Ambrosia dumosa*, and desert-holly (*Atriplex hymenelytra*). Transect A10 occurs on the fine-textured soils north of Goldstone Dry Lake and consisted entirely of *Atriplex polycarpa*.

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DECORANA

DECORANA (Hill 1979b) performed detrended correspondence analysis on the same transects (relative cover data), and the results are presented in Figure 2. In Figure 2A, transects are plotted with respect to first and second axes of the detrended correspondence analysis. These correspond to abiotic parameters that must underlie the distribution of each perennial species. The abscissa (DCA1) apparently correlates with soil texture and soil salinity, with the coarser, nonsaline soils (sand) on the left and the finer (loam to clay), more saline soils on the right. The ordinate (DCA2) does not obviously correspond to a known abiotic parameter but could be soil fertility, with very sterile soils at the bottom and the more fertile soils at the top.

Eight clusters were recognized (Fig. 2A). These are listed below followed by the included transects in parentheses. Asterisked transects are those that were placed in another community by the TWINSpan analysis and bracketed transects are those that were placed in the community by TWINSpan:

- 1) Galleta grass sand fields (60, 66*, 68, 70*, 75*, 140*, and 141).
- 2) Saltbush scrub (1, 42, 44, and A4).
- 3) Allscale scrub (144 and A10).
- 4) Shadscale-creosote bush scrub (24*, 48, 50, 39*, A1*, and A3). [41 and 171].
- 5) Mixed desert scrub (A6, and A7).
- 6) Blackbush-creosote bush transition (9, 54, 97, 104, 106, 130*, 154, 183, and 185). [6, 7, 43, 51, 64, 121, and 173].

7) Creosote bush scrub (2-5, 6*, 7*, 10, 13, 14*, 16*, 17-19, 23, 25-28, 30, 40, 42, 43*, 45-47, 49, 51*, 52, 55-59, 61, 63, 64*, 65, 67, 71, 73, 75, 82, 84, 109*, 115, 121*, 123*, 127, 129, 146, 147, 148, 151*, 155, 159-161, 163-166, 169, 171, 173*, 174, 176, 178, 180, 189, 193, 195, 196*, 198, 199, 200, A2, A5, A8, A9). [130, 66, 70, 75, 140]

8) "Disturbed" (53, 145, and 167). [161].

Figure 2B is a plot of DCA axis 1 versus axis 3. The DCA axis 3 does not appear to aid in the separation of the transects into communities, but it does verify that transects that are in close proximity in Fig. 2A are not widely separated along the third axis.

These results are fairly close to those of TWINSpan (Figure 1), with one noteworthy exception: DECORANA did not distinguish a cluster for cheesebush-senna scrub. Figure 2 of DECORANA has the desirable feature that it illustrates the transitional nature of some of the sites between communities. Transects that cluster together are considered as being from the same plant community and are given the same symbol. Transects have been labeled where the clusters are not too dense. An environmental interpretation of the axes are that DCA axis 1 appears to be correlated with soil texture (sandy soil to left, loams to right) and soil salinity (nonsaline to left, saline to right), DCA axis 2 may be correlated with soil fertility, and DCA axis 3 does not appear to be correlated with an abiotic variable.

Note: These two figures represent two perspectives of the three dimensional scatter of transects along the first three DCA axes. Fig. 2A is an overhead view of the scatter, and Fig. 2B is a lateral view. Eigen values for these first three axes are 0.864, 0.570, and 0.298.

Abbreviations: AS = allscale scrub, BBS = blackbush scrub, CBS = creosote bush scrub, DST = disturbed, GS = galleta grass sand field, MDS = mixed desert scrub, SBS = saltbush scrub, and S-CBS = shadscale creosote bush scrub.

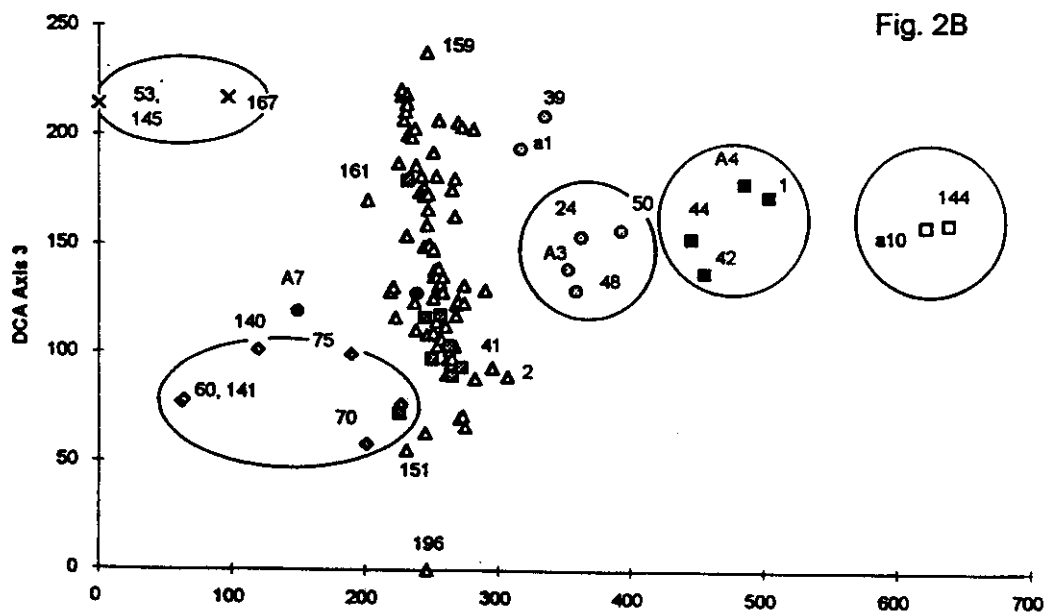
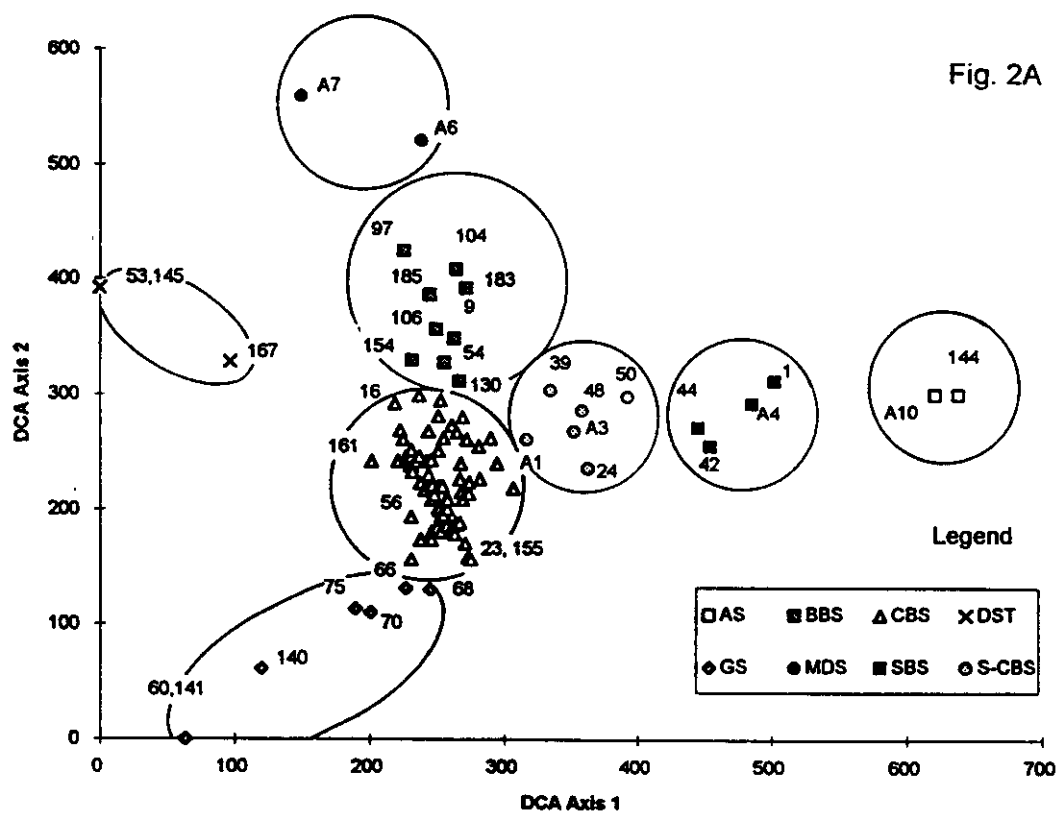


Figure 2. DECORANA of Shrub Cover by Transect.

Cluster Analysis

To classify vegetation samples into plant communities there are several clustering algorithms and similarity or distance measures that commonly are employed. Results usually are presented as dendrograms. The number of different dendrograms that can be generated by various permutations of clustering algorithms and measures of similarity is substantial, and their subsequent interpretations are quite subjective. In practice, the field experience of the researcher is usually indispensable and heavily emphasized in evaluating which dendrogram to use, although comparisons with other techniques and cophenetic analysis are also helpful.

Campbell (1978) offered guidance for choosing a combination of clustering algorithms and similarity measures to produce good results. Using the group average method of clustering, several similarity measures, and some different transformations, he concluded that clustering based on relativized Czekanowski coefficients calculated from arcsine transformed percent absolute cover yielded results that were most comparable to the methods of Braun-Blanquet. Arcsine transformation was recommended because that method gives slightly more weight to less common or low cover species and less weight to the dominant or high cover species. The group average method is equivalent to unweighted pair-group method, arithmetic mean analysis (UPGMA; Sneath and Sokal, 1973), and the relativized Czekanowski coefficient is equivalent to the Bray-Curtis distance measure (Goodall, 1973; Campbell, 1978; Rohlf, 1988) when calculated on relativized data.

Results from several different clustering algorithms, similarity measures, and transformations were obtained on cover

data from the transects. Using the percent absolute cover data, the following transformations were performed: arcsine, relativized, and arcsine + relativized. To interpret results of UPGMA clustering for the four data sets, we used Bray-Curtis distances, Euclidean distances, and product-moment correlations for the similarity measure, and this resulted in selecting the dendrogram based on Bray-Curtis distances calculated from the arcsine + relativized data set. That dendrogram (Fig. 3) was selected because the similarity of clusters agreed closely with the TWINSpan and DECORANA analyses. The cophenetic analysis resulted in a cophenetic correlation of 0.87, which is a good fit (Rohlf, 1988), and it agreed best with field experience in classifying communities.

After obtaining the dendrogram using Bray-Curtis distances calculated from arcsine + relativized data, cluster analyses were performed using each of the following methods: complete linkage, single linkage, flexible linkage with $\beta=0.25$, and weighted pair-group method, arithmetic average (WPGMA). None of the resulting dendrograms were judged to be as useful as the UPGMA clustering selected above.

The results in the selected dendrogram (Fig. 3) agree with the basic groupings identified with DECORANA and TWINSpan, but it is apparent that cluster analysis has more finely subdivided the DECORANA clusters (Fig. 2). On the other hand, the cluster dendrogram failed to illustrate, as did DECORANA and TWINSpan, the transitional nature of some transects, but cluster analysis illustrates other differences that were missed in either DECORANA or TWINSpan.

If a Bray-Curtis distance of 0.6 is used to recognize plant communities, then Figure

3 has 13 clusters. Selecting that value is somewhat arbitrary but based on a balance between the TWINSpan and DECORANA results and pointing out notable significant differences within the cluster analysis.

Heavy vertical lines on the right and labeled with a plant community name reflect the groupings obtained from DECORANA. For creosote bush scrub transects, the transect number is followed by two numbers separated by a slash. The first is the relative cover of *Ambrosia dumosa* and the latter is that of *Larrea tridentata*. Four letter species acronyms following the relative cover values are other species contributing to the recorded cover of the transect. Refer to Appendix I for species acronyms.

Transect 1 clusters by itself, suggesting low affinity with Transects 42 and 44, contrary to that implied by DECORANA (Fig. 2) and TWINSpan (Fig. 1). Although these three transects share *Atriplex spinifera* and *A. confertifolia*, there are some significant differences. Transects 42 and 44 are more saline, located directly on the playa margin, and have appreciable cover of *Artemisia spinescens* (10 percent and 12 percent relative cover, respectively), whereas that species is apparently absent from Transect 1. *Acamptopappus sphaerocephalus* and *Atriplex polycarpa* are common on Transect 1 with 17 percent and 28 percent relative cover, respectively. The latter species does not appear in Transects 42 and 44, although *Acamptopappus* is present in the vicinity.

Transects 48, 50, and A3 clustered together, as in the DECORANA analysis, but Transect 39 is missing and clusters instead with creosote bush scrub. In DECORANA, Transect 39 is peripheral to the shadscale-creosote bush scrub in Figure 2A but clearly separates from it in

Figure 2B.

Transect A4 forms a unary cluster but in DECORANA is grouped with Transects 1, 42, and 44 (Fig. 2). Indeed, A4 is an anomalous site because it appeared to be a disturbed site where the surface had been scraped and only one shrubby species, *Atriplex confertifolia*, had reestablished.

The largest cluster, consisting of 84 transects, is creosote bush scrub. Many of the subclusters within this large cluster illustrate certain patterns. Subcluster of Transects 4 to 200 are generally sites where the cover of *Ambrosia dumosa* is greater than that of *Larrea tridentata*, whereas subcluster of Transects 27 to 115 are generally sites where the reverse occurs. The subcluster of Transects 66, 75, 140, and 151 has significant cover of *Pleuraphis rigida*; using DECORANA these transects appeared in galleta grass sand fields (Fig. 2). Transects 16, 109, 123, and 130 contained *Hymenoclea salsola* and *Senna armata* and clustered together as a cheesebush-senna scrub as in TWINSpan, a wash scrub phase of creosote bush scrub. The last subcluster of creosote bush scrub, Transects 47-A5, are sites where *Larrea* is almost the only shrubby species, not even *Ambrosia dumosa* is encountered in the LCTA transects.

The binary cluster of Transects 70 and 196 appears to be an artificial category. Transect 70 contains species that are typical of galleta grass sand fields and should be classified as such, as it is in the DECORANA treatment. Transect 196 is dominated by *Ambrosia dumosa*, *S. armata*, and *H. salsola* and apparently is a cheesebush-senna scrub site, as it was classified by TWINSpan.

The cluster of Transects 6 to 183 (Fig. 3) represents sites that have high shrub

diversity, and this cluster is approximately equal to the blackbush-creosote bush transition identified with DECORANA (Fig. 2A) and TWINSpan (Fig. 1); in Twinspan Transect 7 also occurs here, but cluster analysis places that site in creosote bush scrub.

The lone Transect 104 is the only transect that can realistically be classified as blackbush scrub.

Transect 97 forms a unary cluster. It has a diverse assemblage of shrubby species, including *Yucca brevifolia* and *Y. schidigera*. This occurs near the upper elevational range of *Larrea tridentata* and represents a transition to the next higher community, Joshua tree woodland.

The triplet formed by transects 53, 145, and 167 are disturbed sites, all of which are dominated by *Stephanomeria pauciflora*. Transect 167 also has significant cover of creosote bush.

Two unary clusters that contain Transects A6 and A7 are from bouldery, granitic slopes, where shrub diversity is relatively high but density and cover tend to be very low. Both sites are classified as mixed desert scrub by DECORANA (Fig. 2A).

Transects 60 and 141 represent the extreme form of galleta grass sand fields. Either this vegetation is naturally very sparse or the plant community is highly disturbed. In Figure 2A of DECORANA these two sites are also plotted as extremes, but Figure 2A illustrates a gradient from this extreme point toward creosote bush scrub through several intermediate sites.

Transects 144 and A10 are dominated by allscale (*Atriplex polycarpa*), and in transect 144 bush seepweed (*Sueada moquinii*) also occurs.

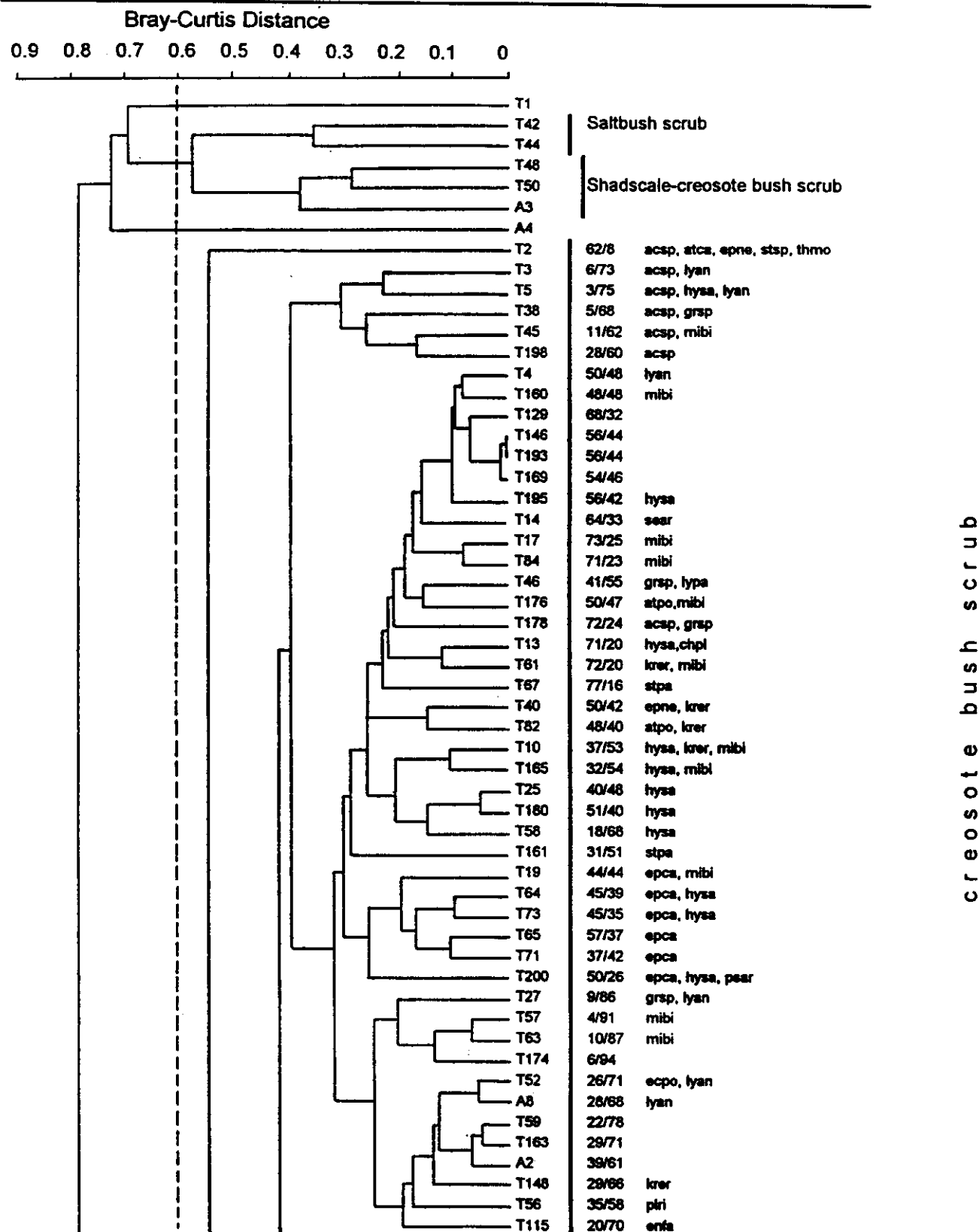
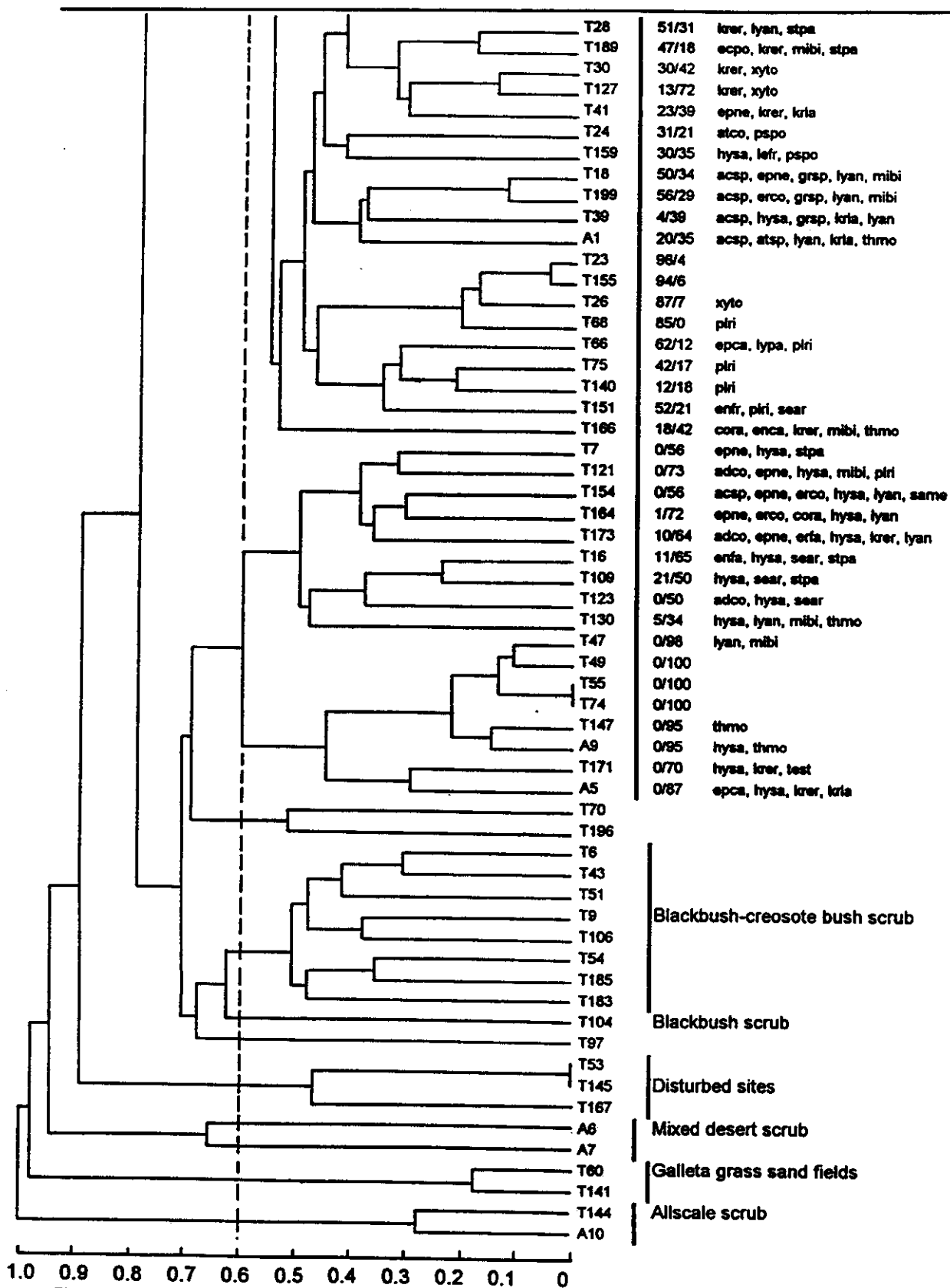


Figure 3. Dendrogram of UPGMA Cluster Analysis of Transect Cover Data.



creosote bush scrub

51/31	krer, lyan, stpa
47/18	ecpo, krer, mibi, stpa
30/42	krer, xyto
13/72	krer, xyto
23/39	epne, krer, kria
31/21	atco, pspo
30/35	hyss, lefr, pspo
50/34	acsp, epne, grsp, lyan, mibi
56/29	acsp, erco, grsp, lyan, mibi
4/39	acsp, hyss, grsp, kria, lyan
20/35	acsp, atsp, lyan, kria, thmo
96/4	
94/6	
87/7	xyto
85/0	plri
62/12	epca, lypa, plri
42/17	plri
12/18	plri
52/21	enfr, plri, sear
18/42	cora, enca, krer, mibi, thmo
0/56	epne, hyss, stpa
0/73	adco, epne, hyss, mibi, plri
0/56	acsp, epne, erco, hyss, lyan, same
1/72	epne, erco, cora, hyss, lyan
10/64	adco, epne, erfa, hyss, krer, lyan
11/65	erfa, hyss, sear, stpa
21/50	hyss, sear, stpa
0/50	adco, hyss, sear
5/34	hyss, lyan, mibi, thmo
0/98	lyan, mibi
0/100	
0/100	
0/100	
0/95	thmo
0/95	hyss, thmo
0/70	hyss, krer, test
0/87	epca, hyss, krer, kria

Blackbush-creosote bush scrub

Blackbush scrub

Disturbed sites

Mixed desert scrub

Galleta grass sand fields

Allscale scrub

Conclusions

The following conclusions based on the preceding analyses and evaluations are partitioned into the respective goals of this project as stated previously. Guidelines are also proposed for generating a plant community map of Fort Irwin.

Goal 1) Determine the Amount of Vegetative Sampling

After conducting several simple field methods, plant cover is concluded to be the most suitable vegetation parameter for the purpose of classifying the vegetation of Fort Irwin. It is also a good index of species dominance. Using the line intercept method for 100-m transects, one can quickly and objectively gather a considerable amount of useful mapping data. On most habitats at Fort Irwin/Goldstone a 100-m transect can be laid with a tape or strong cord and measured for perennial cover within 20 minutes. This time allotment assumes that the researchers can immediately identify every perennial that is encountered along the transect, and accurate identification is essential for classifying the vegetation into communities.

Analyses of existing LCTA 100-m transects revealed that the dominant species are represented but one or more of the common indicator species for the habitat often do not occur. This is especially true for sites with exceptionally low cover, which is often due to heavy disturbance.

Based on line transect simulations, it was determined that a total transect length of 400 meters would be adequate. This transect could be conveniently divided into four 100-m transects or some other division to fit the community being

sampled and avoid traversing wash vegetation or an environmental gradient where plant densities change or there is species replacement, causing two plant assemblages to be summed as one for the analysis. This length of transect would require about 80 minutes for typical alluvial plains and slopes with average plant cover. Higher cover habitats and difficult terrain would take more time. These estimates exclude travel time and, in some cases, time required to locate predetermined sampling sites. Steep slopes, especially those with large boulders or massive outcrops, pose problems and will take considerably longer; they are most easily surveyed along a contour.

The intent of this mapping project should not be to sample quantitatively a majority of the square kilometers on the Reservation but rather to provide a community classification scheme similar to that of Appendix H whereby the surveyor can identify the vegetation to community without quantitative sampling. Only in borderline situations or where more samples are required for more thorough descriptions of a community will quantitative sampling be required.

It is also not the intent of the mapping project to be a monitoring program. If the military wants good quantitative data on changes in cover over time, they will have to continue to rely on monitoring the LCTA transects. Belt transects (pages I-3 and I-4) are the most suitable sampling technique for this purpose. They provide a better measure of density than line-intercepts (more plants are being sampled) as well as reliable cover and species composition data (if the crown diameter method is used to calculate cover).

Goal 2) Determine Suitable Methods for Analyzing the Quantitative Transect Data

Of the various methods used to analyze the transect data, DECORANA provided the most useful results. The graphical presentation of the transects plotted by the first and second and the first and third detrended correspondence components provided a more realistic presentation of results than either TWINSpan or UPGMA cluster analysis. Cluster analysis was useful in identifying transects that might have been misclassified by DECORANA; however, there were more transects that were obviously misplaced by cluster analysis than by DECORANA. We recommend, therefore, that DECORANA be used to define plant communities for the mapping project but in addition a cluster analysis, specifically one using Bray-Curtis distances calculated from arcsine + relativized data, be used to check the DECORANA results for determining whether anomalous affinities were recognized by DECORANA. TWINSpan is useful in establishing species fidelity with community type and may give some additional insights that might be overlooked with only DECORANA.

Goal 3) Identify a Small Set of Perennial Species that Can Be Used as a Reliable Indicator of Each Plant Community

Appendix D is a preliminary characterization of the communities that could be used to classify vegetation into communities. Dominant species are listed, which in most cases should be adequate information to classify the vegetation of a site. Common associates and other characteristic species of low density are listed followed by substrates, elevational ranges, and habitat types, observations that aid in community classification. The list includes some communities not yet quantitatively sampled, and hence, these community descriptions are necessarily vague. The

table will have to be refined and finalized after a complete set of cover data is analyzed.

The team or teams surveying the base must be trained to recognize the dominant and common species of each plant community. For training one or more sample sites of each plant community must be designated as a reference. For Fort Irwin/Goldstone a guide book, with community descriptions similar to Appendix H and photographs of each plant community should be produced.

Mapping needs to be done with a minimum of new transect sampling, using any techniques that minimize field time, because access to The Range will be restricted. Proper training of surveyors and the guidebook will permit sight recognition of most of the communities.

Goal 4) Set Standards for Site Selection for Quantitative Vegetative Sampling for Each Plant Community.

The first priority is to determine the plant community types that have no quantitative cover data or where the sampling has been inadequate. These communities include blackbush scrub, Joshua tree woodland, juniper woodland, mixed desert scrub, galleta grass sand fields, shadscale-creosote bush scrub, alkali sink scrub, wash scrub (including cheesebush-senna scrub, others?) and saltbush scrub. Some of these communities (juniper woodland, alkali sink scrub, and perhaps Joshua tree woodland) have such limited areal extent that only one or two sets of 400-m line intercepts can be sampled. The other communities should be sampled in at least five different sites to get an adequate representation of the range of variability that occurs within the community.

In this analysis the only halophytic vegetation in the database occurs around Goldstone Dry Lake, so that certainly sampling needs to be done around Langford Well Dry Lake, McClean Dry Lake, Nelson Dry Lake, the Bitter Spring area, and others areas where halophytes are common. Also within the new transects should be representative samples of the most sandy localities on the Reservation and along the margins of prominent washes. Vegetation along major washes needs to be sampled with transects for all sectors of the Reservation to quantify one or more forms of Mojave wash scrub, even though a map may not be done at a scale whereon these plant communities can be symbolized.

Certainly juniper woodland will be added to the list of plant communities for Fort Irwin when quantitative data are obtained, because one site has been discovered, in the Avawatz Mountains (Gibson et al., 1994). Sampling of sites with the highest densities of Joshua tree (*Yucca brevifolia*) or of blackbush (*Coleogyne ramosissima*) need to be done to determine whether either of these constitutes a distinctive plant community on the Reservation. Here an effort should be made to find the densest and purest stand of each on the Reservation. The extent of sampling at these higher elevation communities will depend on their areal extent; some, like juniper woodland, occupy such a small area that perhaps only one set of 400-m transects can be surveyed.

Seeps and springs have been visited and are unique enough that sampling is not required, and for most the patch of vegetation is too small to utilize the standard transect method and too small to represent variants on a map.

Just from the above mentioned sites, at least 40 new transects need to be done.

The second priority is to review low elevation aerial photographs and videos and delineate areas where ground surveys are desirable. Establishing correlations between photographic signatures and plant communities will permit much of the mapping to be done from photographs or videos. Video recordings from a helicopter, if done at regular distances across the property and with a vertically oriented camera, could be used to resolve some of the time constraints and accessibility problems of a project done entirely on the ground.

A decision needs to be made at the start of the project whether the northwestern corner of the base will be included in the mapping project. To date very little floristic or ecological research has been done there because Leach Lake and the Quail Mountains are off limits due to dangerous ordinance conditions. Because this is the closest portion of the Reservation to Death Valley National Park, plant species and communities from that area may be expected to occur.

A decision also needs to be made whether all LCTA sites should also be included in the database, which would require determining cover values for about 100 LCTA transects as well. Methods used on the LCTA transects prior to 1993 are not considered very reliable because of undersampling.

Guidelines for Generating a Plant Community Map of Fort Irwin/Goldstone

- 1) Develop a complete data base containing plant cover values for all major variations in vegetation on Fort Irwin.
- 2) Analyze the complete data set to classify the vegetation into plant communities. Once all the different vegetation sites have been sampled, the

complete data set of cover values will be analyzed, and the plant community classification finalized. DECORANA is the preferred method of analysis, but TWINSPLAN and UPGMA cluster analysis are also useful because they may identify transects that have been misclassified.

3) For the communities from the above classification generate descriptions that can be used to identify the vegetation of sites into plant communities. These descriptions will include dominant, common species, and other diagnostic species along with substrate, habitat, elevational ranges, and representative pictures of the community. These descriptions should enable one to identify most sites without having to do quantitative sampling.

4) Survey Fort Irwin NTC. Surveys should be done in the springtime, when the perennials have leaves and often reproductive structures, to permit accurate identification. Bunchgrasses are often unidentifiable for up to eight months of the year, and drought-deciduous shrubs can be confused when leaves are no longer present.

For plains adequate mapping along trails and paths can be done by an experienced team usually without leaving the vehicle. Vegetation can be scored every 0.1 or 0.2 km on either side of the trail, and where military maneuvers occur, much of the area will be designated as disturbed. All sites where vegetation is classified will be given coordinates based on the Universal Transverse Mercator grid system.

Alternatively, video recordings from helicopter passes or a good set of low elevation aerial photographs would facilitate mapping and would be indispensable in defining the boundaries between communities.

Any site that does not fit a definition for a plant community should be sampled with 400-m transects, and each can be added to the database to be analyzed by DECORANA for its assignment to an existing community or its recognition as a new community for the Reservation. Because most habitats sampled to date were dominated by *Larrea tridentata*, it is unlikely that additional sampling will permit greater refinement in the definition of creosote bush communities.

Low elevation vegetation probably can be surveyed fairly rapidly first by plotting boundaries of all plant communities *except* creosote bush scrub. To do this a team would locate the special habitats from higher vantage points, sample along the existing maze of major and minor roads and trails, and sample in radii from the original transects and playa margins. Elevation readings, like benchmarks, should be taken at the borderline of each plant community to help to fix data points, and these values may be useful in the future to document expansion or contraction of particular habitats.

Many areas of the Reservation will require special decisions on how best to survey. Granite outcrops with large boulders can be surveyed around the bases, where more extensive granite landforms, such as those separating major valleys of Fort Irwin, need to be surveyed by air and partially botanized on the ground, because some special plant species may occur. The "Whale," a small, volcanic mountain west of Bitter Spring, should be carefully botanized as mapping is being done, especially along washes cut into the base of the landform and in sand fields around its base. Because upper alluvial fans and the largest mountainous regions have little road access, use of binoculars or aerial survey will probably be the most efficient way to enter points on a vegetation map; nonetheless, important peaks and canyons

must be visited on foot to look for and document special plant communities. Mountains constitute less than 10 percent of the total of the Reservation but probably will require 90 percent of field time to map.

5) Generate a plant community map of Fort Irwin NTC. Symbols for mapping the plant communities need to be chosen so that they can be entered into a computer and on wall maps as soon as they are surveyed. The initial points would be the 155 (or 255) transects used in the second generation DECORANA analysis. The most common plant community should have the simplest and lightest symbol, and the highly restricted and isolated ones should have the most complex or more solid ones, to be easily observed by the map user. A disturbance designation (dashes or slashes) would be superimposed on the plant community symbol. The final vegetation map should inform the user where natural vegetation has been heavily damaged or no longer occurs. A habitat that has been scraped of its original plant community but which is currently colonized by a different plant assemblage should also be connoted with a disturbance symbol.

Any zone that has not been analyzed should be indicated as unexplored (blank), rather than mapped with unverified symbols as particular plant communities.

We do not think that level of disturbance can be represented quantitatively on a vegetation map, because that would require a blanket of 400-m transects to document percent cover on disturbed sites as compared with neighboring undisturbed sites.

Codes should be assigned to a short list of special plants and placed into the computer database by UTM coordinates wherever found on the Reservation. This way a map can be produced for each of

these in the future. Perhaps locations of trees should be placed directly on the map, because they are so seldom observed, and if neither *Yucca brevifolia*, mesquite (*Prosopis glandulosa* var. *torreyana*), desert willow (*Chilopsis linearis*), and Goodding's black willow (*Salix gooddingii*), tamarisk (*Tamarix ramosissima*) are used as dominants of a particular plant community, we recommend that Y, P, C, S, and T, respectively, be used to designate stands of these at particular coordinates. Places where either *T. ramosissima* or a species of *Eucalyptus* has invaded can also be indicated. Designating locations of trees will benefit users by showing how woodlands may have expanded or contracted and probably help to define the abiotic conditions of those particular localities.

6) All mapping data will be given UTM coordinates to the nearest 100 m, so that a map with a resolution of 100 X 100 m can be generated. Final maps will be at a scale of 1:100,000

The map with plant communities should be entered into a Geographical Information System (GIS), which needs to be established on the military base. At least two terminals should be established, one at the NTS Directorate of Public Works, Environmental Division, and the other in the Environmental Division at Echo Station on Goldstone. Placed into that GIS should be all relevant ecological and biological data about Fort Irwin organisms.

REFERENCES

- Barbour, M.G. 1969. Age and space distribution of the desert shrub *Larrea divaricata*. *Ecology* 50:679-685.
- Beatley, J.C. 1969. Dependence of desert rodents on winter annuals and precipitation. *Ecology* 50:721-724.
- Beatley, J.C. 1974a. Phenological events and their environmental triggers in Mojave Desert ecosystems. *Ecology* 55:856-863.
- Beatley, J.C. 1974b. Effects of rainfall and temperature on the distribution and behavior of *Larrea tridentata* (Creosote-bush) in the Mojave Desert of Nevada.
- Campbell, B.M. 1978. Similarity coefficients for classifying relevés. *Vegetation* 27:101-109.
- Donnelly, M. and Van Ness, J. G. 1986. The warrior and the Druid--DOD and Environmental Law. *Federal Bar News and Journal* 33: 37-43.
- Ferrús-García, A. 1995. Report on 1993 LCTA vegetation monitoring at Fort Irwin, California. Prepared for the Directorate of Public Works, U. S. Army National Training Center, Fort Irwin, CA.
- Gauch, H.G., Jr. 1982. *Multivariate Analysis in Community Ecology*. Cambridge Univ. Press, London.
- Gibson, A. C., Prigge, B. A., Niessen, K. 1994. Floral surveys at the Fort Irwin National Training Center, San Bernardino, California. Prepared for the Directorate of Public Works, U. S. Army National Training Center, Fort Irwin, CA. 33 pp. plus appendices.
- Goodall, D.W. 1973. Sample similarity and species correlation. IN R.H. Whittaker (Ed.), *Ordination and Classification of Communities*, pp. 105-156. Junk Publ., The Hague.
- Hill, M.O. 1979a. DECORANA, a FORTRAN program for detrended correspondence analysis and reciprocal averaging. Cornell University, Ithaca, N.Y.
- Hill, M.O. 1979b. TWINSpan, a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individual and attributes. Cornell University, Ithaca, N.Y.
- Hill, M.O., Bunce, R.G.H., & Shaw, M.W. 1975. Indicator species analysis, a divisive polythetic method of classification, and its application to a survey of native pinewoods in Scotland. *Journal of Ecology* 63:597-613.
- Johnson, R. 1988. *Elementary statistics*. PWS-KENT Publishing Company. Boston, MA.
- Krzysik, A. J. 1985. Ecological assessment of the effects of army training activities on a desert ecosystem: National Training Center, Fort Irwin, California. U.S. Army Corps of Engineers Construction Engineering Research Laboratory. Technical Report N-85/13. 127 pp. plus appendices.
- Leitner, P, and Leitner, B. M. 1992. Coso grazing exclosure monitoring study, 1992 report, Coso Known geothermal resource area, Inyo County, California. Prepared for Jean Hopkins and Associates, Inc. Bethesda, MD. 64 pp. plus appendices.
- Lunt, O.R., Letey, J., and Clark, S.B. 1973. Oxygen requirements for root growth in three species of desert shrubs. *Ecology* 54:1356-1362.

Mueller-Dombois, D., & Ellenberg, H. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, N.Y.

Muller, C.H. 1953. The association of desert annuals with shrubs. American Journal of Botany 40:53-60.

Oosting, H.J. 1956. The study of plant communities. W.H. Freeman and Co., San Francisco, CA.

Rohlf, F.J. 1988. NTSYS-pc, Numerical Taxonomy and Multivariate Analysis System, Version 1.40. Exeter Publ., Ltd., Setauket, N.Y.

Shaw, R.B. 1990. Land Condition/Trend Analysis Installation Report, Fort Irwin, California, National Training Center.

Sneath, P.H.A. & Sokal, R.R. 1973. Numerical Taxonomy. W.H. Freeman and Co., San Francisco, CA.

APPENDICES

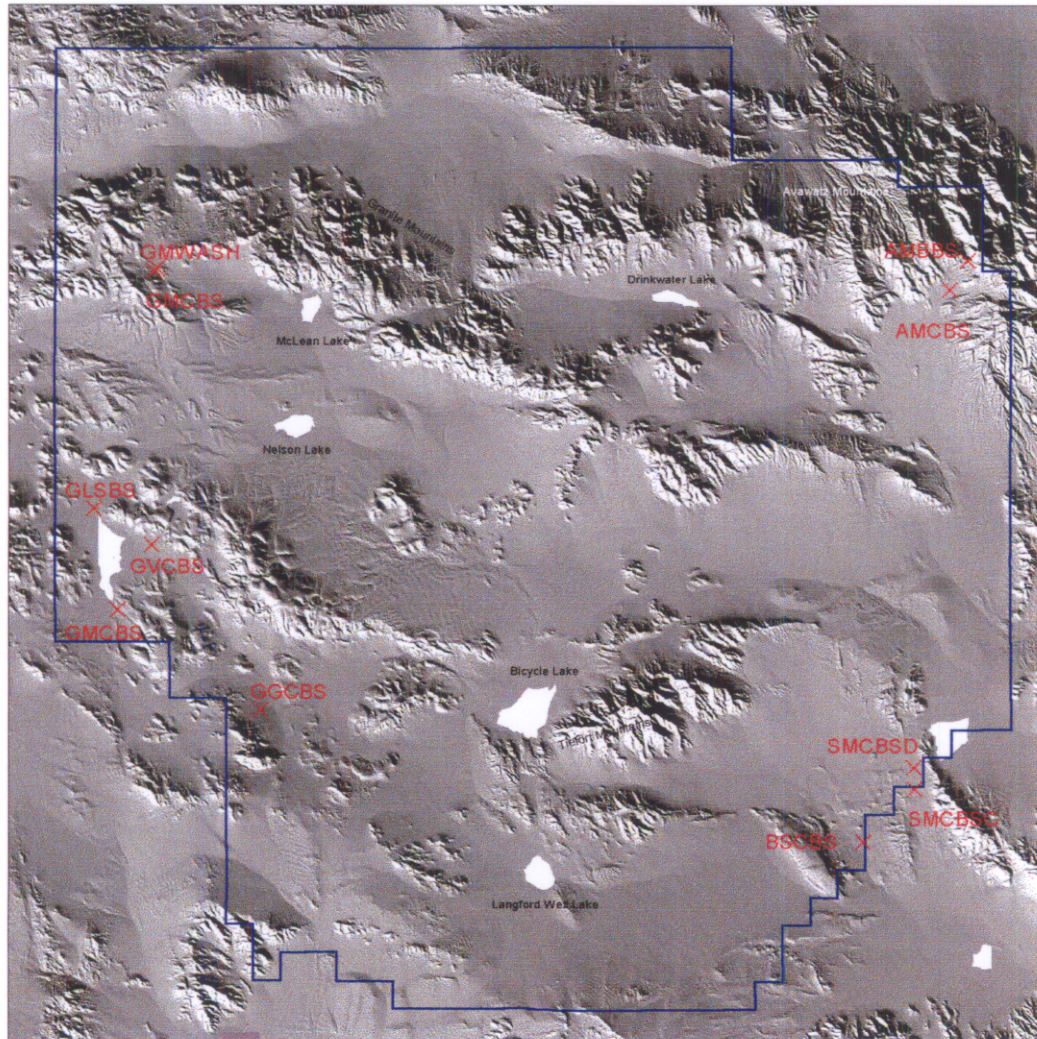
Appendix A

Acronyms, UTM Coordinates, Elevation, Slope and Aspect of Vegetation Monitoring Study Sites Surveyed in 1994. Arranged alphabetically by acronym.

Acronym	Study Site	Northing	Easting	Elevation	Slope	Aspect
AMBBS	Avawatz Mtns Blackbush Scrub	393018	559474	1602	16%	West
AMCBS	Avawatz Mtns Creosote Bush Scrub	392847	558445	1412	10%	Southwest
BSCBS	Bitter Springs Creosote Bush Scrub	389646	553415	425	2%	West-SW
GGCBS	Goldstone Granitic Creosote Bush Scrub	390411	518546	990	8%	North
GVCBS	Goldstone Volcanic Creosote Bush Scrub	391369	512253	973	5%	South
GMCBS	Goldstone Mixed Creosote Bush Scrub	390988	510281	955	1%	West
GLSBS	Goldstone Lake Saltbrush Scrub	391576	508922	943	0-1%	-----
GMGCB	Granite Mtns Granitic Creosote Bush Scrub	392953	512373	1207	7%	North-NE
GMWASH	Granite Mtns Desert Wash Scrub	392969	512607	1200	4%	Southeast
SMCBSC	Soda Mtns Creosote Bush Scrub Control	389950	556383	564	7%	West
SMCBSD	Soda Mtns Creosote Bush Scrub Disturbed	380080	556379	569	7%	West

[illegible]

Appendix B. Location of vegetation monitoring sites surveyed in 1994.



- × Study Sites
- Fort Irwin Boundary



Appendix C.

Tables from the Analysis of Variance Performed on Percent Cover Values for All Study Sites.

Avawatz Mountains Blackbush Scrub Study Site

Anova: Single Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Transect A	4	2.94929	0.73732	0.00544
Transect B	4	2.77592	0.69398	0.00248

ANOVA

<i>Source of</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.00375	1	0.00375	0.94768	0.36790	5.98737
Within Groups	0.02378	6	0.00396			
Total	0.02754	7				

Avawatz Mountains Creosote Bush Scrub Study Site

Anova: Single Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Transect A	4	2.69911	0.67477	0.00105
Transect B	4	2.86279	0.71569	0.00308

ANOVA

<i>Source of</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.00334	1	0.00334	1.61597	0.25071	5.98737
Within Groups	0.01243	6	0.00207			
Total	0.01578	7				

Appendix C (continued).

Bitter Springs Creosote Bush Scrub Study Site

Anova: Single Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Transect A	4	1.36489	0.34122	0.00058
Transect B	4	1.48195	0.37049	0.00089

ANOVA

<i>Source of</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.00171	1	0.00171	2.30500	0.17975	5.98737
Within Groups	0.00445	6	0.00074			
Total	0.00617	7				

Goldstone Granitic Creosote Bush Scrub Study Site

Anova: Single Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Transect A	4	2.54551	0.63638	0.00011
Transect B	4	2.40989	0.60247	0.00180

ANOVA

<i>Source of</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.00229	1	0.00229	2.39854	0.17241	5.98737
Within Groups	0.00575	6	0.00095			
Total	0.00805	7				

Goldstone Lake Saltbush Scrub Study Site

Anova: Single Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Transect A	4	1.53631	0.38407	0.00228
Transect B	4	0.98339	0.24584	0.00123

Appendix C (continued).

ANOVA

Source of	SS	df	MS	F	P-value	F crit
Between Groups	0.03821	1	0.03821	21.7073	0.00347	5.98737
Within Groups	0.01056	6	0.00176			
Total	0.04877	7				

Goldstone Mixed Creosote Bush Scrub Study Site

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Transect A	4	1.92835	0.48208	0.00329
Transect B	4	1.85974	0.46493	0.00088

ANOVA

Source of	SS	df	MS	F	P-value	F crit
Between Groups	0.00058	1	0.00058	0.28174	0.61462	5.98737
Within Groups	0.01252	6	0.00208			
Total	0.01311	7				

Granite Mountains Creosote Bush Scrub Study Site

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Transect A	4	2.39953	0.59988	0.00318
Transect B	4	2.44089	0.61022	0.00589

ANOVA

Source of	SS	df	MS	F	P-value	F crit
Between Groups	0.00021	1	0.00021	0.04711	0.83536	5.98737
Within Groups	0.02722	6	0.00453			
Total	0.02744	7				

Appendix C (continued).

Goldstone Volcanic Creosote Bush Study Site

Anova: Single Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Transect A	4	1.79886	0.44971	0.00098
Transect B	4	1.65552	0.41388	0.00174

ANOVA

<i>Source of</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.00256	1	0.00256	1.88269	0.21911	5.98737
Within Groups	0.00818	6	0.00136			
Total	0.01075	7				

Soda Mountains Creosote Bush Scrub Control Study Site

Anova: Single Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Transect A	4	1.58440	0.39610	0.00483
Transect B	4	1.34174	0.33543	0.00038

ANOVA

<i>Source of</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.00736	1	0.00736	2.81921	0.14414	5.98737
Within Groups	0.01566	6	0.00261			
Total	0.02302	7				

Appendix C (continued)

Soda Mountains Creosote Bush Scrub Disturbed Study Site

Anova: Single Factor

SUMMARY

<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Transect A	4	1.05032	0.26258	0.00079
Transect B	4	1.17148	0.29287	0.00129

ANOVA

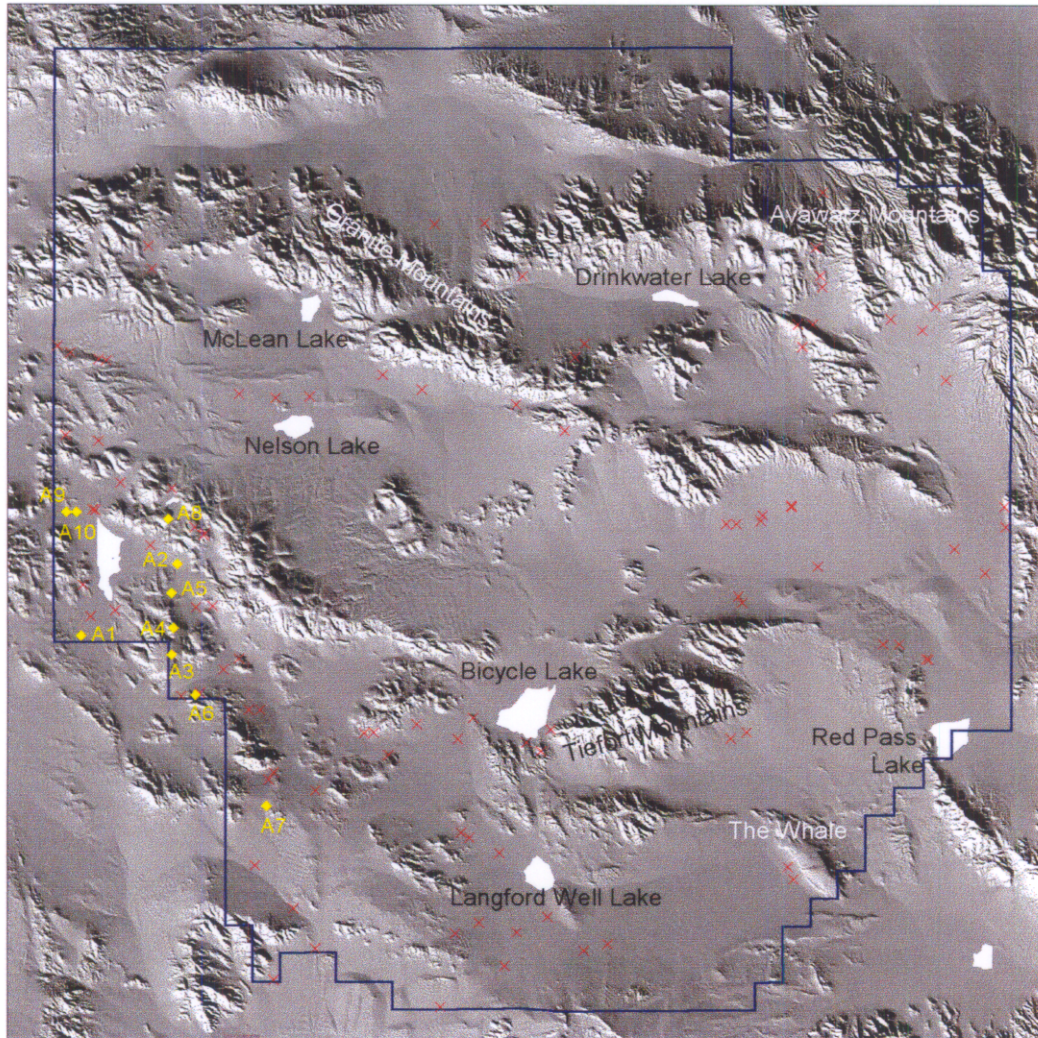
<i>Source of</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.00183	1	0.00183	1.76004	0.23287	5.98737
Within Groups	0.00625	6	0.00104			
Total	0.00809	7				

Appendix D.

Classification of plant communities used in the recent floristic survey of Fort Irwin/Goldstone Military Reservation (Gibson, Prigge, and Niessen, 1994).

Creosote bush scrub
Creosote bush-galleta grass scrub
Saltbush scrub
Alkali sink scrub
Joshua tree woodland
Blackbush scrub
Juniper woodland
Mixed desert scrub
Desert wash scrub
"Seeps and springs"

Appendix E. Location of vegetation mapping transects.



- ◆ 1994 Mapping Transects
- × 1993 LCTA Transects
- Fort Irwin Boundary



Appendix F.

**Location in UTM Coordinates of Vegetation Mapping Transects Sampled in 1994.
Arranged alphabetically by transect ID.**

Study Site	Easting	Northing
A1	50824	390842
A2	51382	391258
A3	51346	390733
A4	51359	390888
A5	51346	391089
A6	51484	390500
A7	51845	389858
A8	51330	391520
A9	50740	391560
A10	50800	391560

Appendix G. Species cover (cm) per 100 m transects. See Appendix I for acronyms.

species	Transects												
	T1	T2	T3	T4	T5	T6	T7	T9	T10	T13	T14	T16	T17
acsp	144	76	23	0	235	0	0	0	0	0	0	0	0
adco	0	0	0	0	0	0	0	0	0	0	0	0	0
amdu	0	1290	71	935	135	883	0	181	1045	594	635	65	1592
arsp	0	0	0	0	0	0	0	0	0	0	0	0	0
atca	124	175	0	0	0	0	0	0	0	0	0	0	0
atco	175	0	0	0	0	0	0	0	0	0	0	0	0
atpo	231	0	0	0	0	0	0	0	0	0	0	0	0
atsp	0	0	0	0	0	0	0	0	0	0	0	0	0
chte	0	0	0	0	0	0	0	0	0	0	0	0	0
cora	0	0	0	0	0	0	0	122	0	0	0	0	0
crca	0	0	0	0	0	0	0	0	0	0	0	0	0
ecpo	0	0	0	0	0	0	0	0	0	0	0	0	0
enac	0	0	0	0	0	0	0	5	0	0	0	0	0
enfa	0	0	0	0	0	0	0	0	0	0	0	50	0
enfr	0	0	0	0	0	0	0	0	0	0	0	0	0
epca	0	0	0	0	0	0	0	0	0	0	0	0	0
epne	0	109	0	0	0	25	60	660	0	0	0	0	0
epvi	0	0	0	0	0	0	0	0	0	0	0	0	0
erco	0	0	0	0	0	0	0	0	0	0	0	0	0
ercu	0	0	0	0	0	0	0	0	0	0	0	0	0
erfa	0	0	0	0	0	335	0	320	0	0	0	0	0
grsp	0	0	0	0	0	0	0	0	0	0	0	0	0
gumi	0	0	0	0	0	0	0	0	0	0	0	0	0
hyse	42	0	0	0	460	55	409	0	80	66	0	210	0
krer	0	0	0	0	0	0	0	45	100	0	0	0	0
krla	0	0	0	0	0	0	0	0	0	0	0	0	0
latr	0	175	914	885	2960	555	700	485	1500	169	330	145	555
lefr	0	0	0	0	0	0	0	0	0	0	0	0	0
lepu	0	0	0	0	0	0	0	0	0	0	0	0	0
lyan	102	0	219	30	150	10	0	25	0	0	0	0	0
lypa	0	0	0	0	0	0	0	0	0	0	0	0	0
mibi	0	0	0	0	0	50	0	0	100	0	0	0	25
opba	0	0	0	0	0	0	0	15	0	0	0	0	0
pali	0	0	0	0	0	0	0	0	0	0	0	0	0
plri	0	0	0	0	0	0	0	0	0	0	0	0	0
psar	0	0	0	0	0	0	0	0	0	0	0	0	0
pspo	0	0	0	0	0	0	0	0	0	0	0	0	0
same	0	0	0	0	0	0	0	0	0	0	0	0	0
samo	0	0	0	0	0	0	0	0	0	0	0	0	0
sear	0	0	0	0	0	0	0	0	0	0	35	65	0
stpa	0	0	0	0	0	0	0	0	0	0	0	50	0
stsp	0	124	0	0	0	0	75	63	0	0	0	0	0
sumo	0	0	0	0	0	0	0	0	0	0	0	0	0
test	0	0	0	0	0	0	0	0	0	0	0	0	0
thmo	0	116	0	0	0	0	0	0	0	0	0	0	0
xyto	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	818	2065	1227	1850	3940	1913	1244	1921	2825	829	1000	585	2172

Appendix G (continued)

species	Transects												
	T42	T43	T44	T45	T46	T47	T48	T49	T50	T51	T52	T53	T54
acsp	0	60	0	332	0	0	0	0	0	0	0	0	0
adco	0	0	0	0	0	0	0	0	0	0	0	0	0
amdu	410	1260	127	168	727	0	90	0	70	450	450	0	675
arsp	150	0	86	0	0	0	0	0	0	0	0	0	0
atca	0	0	0	0	0	0	0	0	0	0	0	0	0
atco	480	0	449	0	0	0	355	0	760	0	0	0	0
atpo	300	0	0	0	0	0	0	0	0	0	0	0	0
atsp	0	0	0	0	0	0	0	0	0	0	0	0	0
chte	0	105	0	0	0	0	0	0	0	0	0	0	0
cora	0	0	0	0	0	0	0	0	0	0	0	0	0
crca	0	0	0	0	0	0	0	0	0	0	0	0	0
ecpo	0	0	0	0	0	0	0	0	0	0	15	0	0
enac	0	20	0	0	0	0	0	0	0	0	0	0	166
enfa	0	0	0	0	0	0	0	0	0	0	0	0	0
enfr	0	0	0	0	0	0	0	0	0	0	0	0	0
epca	0	0	0	0	0	0	0	0	0	0	0	0	0
epne	0	140	0	0	0	0	55	0	30	0	0	0	241
epvi	0	0	0	0	0	0	0	0	0	10	0	0	0
erco	0	50	0	0	0	0	0	0	0	0	0	0	102
ercu	0	0	0	0	0	0	0	0	0	0	0	0	0
erfa	0	370	0	0	0	0	0	0	70	50	0	0	52
grsp	0	0	0	0	30	0	0	0	0	0	0	0	128
gumi	0	0	0	0	0	0	0	0	0	0	0	0	0
hysa	0	115	0	0	0	0	0	0	0	105	0	0	0
krer	0	0	0	0	0	0	375	0	160	0	0	0	0
krle	120	0	0	0	0	0	15	0	30	0	0	0	0
latr	0	415	0	950	983	2030	275	1937	300	20	1205	0	488
lefr	0	0	0	0	0	0	0	0	0	0	0	0	0
lepu	0	0	0	0	0	0	0	0	0	0	0	0	0
lyan	0	15	57	0	0	35	0	0	140	115	35	0	125
lypa	0	0	0	0	0	0	0	0	0	0	0	0	0
mibi	0	115	0	66	30	5	0	33	0	0	0	0	16
opba	0	0	0	0	0	0	15	0	0	0	0	0	0
pali	0	0	0	0	0	0	0	0	0	0	0	0	0
plri	0	0	0	0	0	0	0	0	0	0	0	0	0
psar	0	0	0	0	0	0	0	0	0	0	0	0	0
pspo	0	0	0	0	0	0	0	0	0	0	0	0	0
same	0	45	0	0	0	0	0	0	0	0	0	0	374
samo	0	0	0	0	0	0	0	0	0	0	0	0	0
sear	0	0	0	0	0	0	0	0	0	0	0	0	0
stpa	0	0	0	0	0	0	0	0	0	0	0	30	0
stsp	0	0	0	0	0	0	0	0	40	0	0	0	0
sumo	0	0	0	0	0	0	0	0	0	0	0	0	0
test	0	0	0	0	0	0	0	0	0	0	0	0	0
thmo	0	95	0	0	0	0	0	0	0	0	0	0	118
xyto	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1460	2805	719	1516	1770	2070	1180	1970	1600	750	1705	30	2485

Appendix G (continued)

species	Transects												
	T42	T43	T44	T45	T46	T47	T48	T49	T50	T51	T52	T53	T54
acsp	0	60	0	332	0	0	0	0	0	0	0	0	0
adco	0	0	0	0	0	0	0	0	0	0	0	0	0
amdu	410	1260	127	168	727	0	90	0	70	450	450	0	675
arsp	150	0	86	0	0	0	0	0	0	0	0	0	0
atca	0	0	0	0	0	0	0	0	0	0	0	0	0
atco	480	0	449	0	0	0	355	0	760	0	0	0	0
atpo	300	0	0	0	0	0	0	0	0	0	0	0	0
atsp	0	0	0	0	0	0	0	0	0	0	0	0	0
chte	0	105	0	0	0	0	0	0	0	0	0	0	0
cora	0	0	0	0	0	0	0	0	0	0	0	0	0
crca	0	0	0	0	0	0	0	0	0	0	0	0	0
ecpo	0	0	0	0	0	0	0	0	0	0	15	0	0
enac	0	20	0	0	0	0	0	0	0	0	0	0	166
enfa	0	0	0	0	0	0	0	0	0	0	0	0	0
enfr	0	0	0	0	0	0	0	0	0	0	0	0	0
epca	0	0	0	0	0	0	0	0	0	0	0	0	0
epne	0	140	0	0	0	0	55	0	30	0	0	0	241
epvi	0	0	0	0	0	0	0	0	0	10	0	0	0
erco	0	50	0	0	0	0	0	0	0	0	0	0	102
ercu	0	0	0	0	0	0	0	0	0	0	0	0	0
erfa	0	370	0	0	0	0	0	0	70	50	0	0	52
grsp	0	0	0	0	30	0	0	0	0	0	0	0	128
gumi	0	0	0	0	0	0	0	0	0	0	0	0	0
hysa	0	115	0	0	0	0	0	0	0	105	0	0	0
krer	0	0	0	0	0	0	375	0	160	0	0	0	0
krla	120	0	0	0	0	0	15	0	30	0	0	0	0
latr	0	415	0	950	983	2030	275	1937	300	20	1205	0	488
lefr	0	0	0	0	0	0	0	0	0	0	0	0	0
lepu	0	0	0	0	0	0	0	0	0	0	0	0	0
lyan	0	15	57	0	0	35	0	0	140	115	35	0	125
lypa	0	0	0	0	0	0	0	0	0	0	0	0	0
mibi	0	115	0	66	30	5	0	33	0	0	0	0	16
opba	0	0	0	0	0	0	15	0	0	0	0	0	0
pali	0	0	0	0	0	0	0	0	0	0	0	0	0
plri	0	0	0	0	0	0	0	0	0	0	0	0	0
psar	0	0	0	0	0	0	0	0	0	0	0	0	0
pspo	0	0	0	0	0	0	0	0	0	0	0	0	0
same	0	45	0	0	0	0	0	0	0	0	0	0	374
samo	0	0	0	0	0	0	0	0	0	0	0	0	0
sear	0	0	0	0	0	0	0	0	0	0	0	0	0
stpa	0	0	0	0	0	0	0	0	0	0	0	30	0
stsp	0	0	0	0	0	0	0	0	40	0	0	0	0
sumo	0	0	0	0	0	0	0	0	0	0	0	0	0
test	0	0	0	0	0	0	0	0	0	0	0	0	0
thmo	0	95	0	0	0	0	0	0	0	0	0	0	118
xyto	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1460	2805	719	1516	1770	2070	1180	1970	1600	750	1705	30	2485

Appendix G (continued)

species	Transects												
	T55	T56	T57	T58	T59	T60	T61	T63	T64	T65	T66	T67	T68
acsp	0	0	0	0	0	0	0	0	0	0	0	0	0
adco	0	0	0	0	0	0	0	0	0	0	0	0	0
amdu	0	45	40	245	125	0	900	236	410	720	750	855	470
arsp	0	0	0	0	0	0	0	0	0	0	0	0	0
atca	0	0	0	0	0	0	0	0	0	0	0	0	0
atco	0	0	0	0	0	0	0	0	0	0	0	0	0
atpo	0	0	0	0	0	0	0	0	0	0	0	0	0
atsp	0	0	0	0	0	0	0	0	0	0	0	0	0
chte	0	0	0	0	0	0	0	0	0	0	0	0	0
cora	0	0	0	0	0	0	0	0	0	0	0	0	0
crca	0	0	0	0	0	15	0	0	0	0	0	0	0
ecpo	0	0	0	0	0	0	0	0	0	0	0	0	0
enac	0	0	0	0	0	0	0	0	0	0	0	0	0
enfa	0	0	0	0	0	0	0	0	0	0	0	0	0
enfr	0	0	0	0	0	0	0	0	0	0	0	0	0
epca	0	0	0	0	0	0	0	0	50	75	100	0	0
epne	0	0	0	0	0	0	0	0	0	0	0	0	0
epvi	0	0	0	0	0	0	0	0	0	0	0	0	0
erco	0	0	0	0	0	0	0	0	0	0	0	0	0
ercu	0	0	0	0	0	0	0	0	0	0	0	0	0
erfa	0	0	0	0	0	0	0	0	0	0	0	0	0
grsp	0	0	0	0	0	0	0	0	0	0	0	0	0
gumi	0	0	0	0	0	0	0	0	0	0	0	0	0
hysa	0	0	0	175	0	0	60	0	80	0	0	0	0
krer	0	0	0	0	0	0	0	0	0	0	0	0	0
krle	0	0	0	0	0	0	0	0	0	0	0	0	0
latr	630	75	860	905	450	0	245	2030	360	460	155	185	0
lefr	0	0	0	0	0	0	0	0	0	0	0	0	0
lepu	0	0	0	0	0	0	0	0	0	0	0	0	0
lyan	0	0	0	0	0	0	0	0	0	0	0	0	0
lypa	0	0	0	0	0	0	0	0	0	0	10	0	0
mibi	0	0	40	0	0	0	50	60	0	0	0	0	0
opba	0	0	0	0	0	0	0	0	0	0	0	0	0
pali	0	0	0	0	0	0	0	0	10	0	0	0	0
plri	0	10	0	0	0	350	0	0	0	0	200	0	80
psar	0	0	0	0	0	0	0	0	0	0	0	0	0
pspo	0	0	0	0	0	0	0	0	0	0	0	0	0
same	0	0	0	0	0	0	0	0	0	0	0	0	0
samo	0	0	0	0	0	0	0	0	0	0	0	0	0
sear	0	0	0	0	0	0	0	0	0	0	0	0	0
stpa	0	0	0	0	0	0	0	0	0	0	0	75	0
stsp	0	0	0	0	0	0	0	0	0	0	0	0	0
sumo	0	0	0	0	0	0	0	0	0	0	0	0	0
test	0	0	0	0	0	0	0	0	0	0	0	0	0
thmo	0	0	0	0	0	0	0	0	0	0	0	0	0
xyto	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	630	130	940	1325	575	365	1255	2326	910	1255	1215	1115	550

Appendix G (continued)

species	Transects												
	T70	T71	T73	T74	T75	T82	T84	T97	T104	T106	T109	T115	T121
acsp	0	0	0	0	50	0	0	0	0	0	0	0	0
adco	0	0	0	0	0	0	0	0	35	0	0	0	85
amdu	200	185	685	0	1025	210	385	0	0	140	135	310	0
arsp	0	0	0	0	0	0	0	0	0	0	0	0	0
atca	0	0	0	0	0	0	0	0	0	0	0	0	0
atco	0	0	0	0	0	0	0	0	0	0	0	0	0
atpo	0	0	0	0	0	5	0	0	0	0	0	0	0
atsp	0	0	0	0	0	0	0	0	0	0	0	0	0
chte	0	0	0	0	0	0	0	0	0	0	0	0	0
cora	0	0	0	0	0	0	0	0	730	145	0	0	0
crca	50	0	0	0	0	0	0	0	0	0	0	0	0
ecpo	0	0	0	0	0	0	0	0	0	0	0	0	0
enac	0	0	0	0	0	0	0	0	80	0	0	0	0
enfa	0	0	0	0	0	0	0	0	0	0	0	150	0
enfr	0	0	0	0	0	0	0	0	0	0	0	0	0
epca	60	100	225	0	0	0	0	0	0	0	0	0	0
epne	0	0	0	0	0	0	0	0	345	15	0	0	110
epvi	0	0	0	0	0	0	0	0	0	0	0	0	0
erco	0	0	0	0	0	0	0	0	185	0	0	0	0
ercu	0	0	0	0	0	0	0	0	0	0	0	0	0
erfa	0	0	0	0	0	0	0	1027	140	350	0	0	0
grsp	0	0	0	0	0	0	0	0	220	0	0	0	0
gumi	0	0	0	0	0	0	0	0	0	0	0	0	0
hysa	30	0	65	0	0	0	0	286	500	150	60	0	109
krer	0	0	0	0	0	45	0	0	0	35	0	0	0
krla	0	0	0	0	0	0	0	0	0	0	0	0	0
latr	0	210	545	920	420	175	125	90	0	235	320	1098	1035
lefr	0	0	0	0	0	0	0	0	0	0	0	0	0
lepu	0	0	0	0	0	0	0	0	0	0	0	0	0
lyan	0	0	0	0	0	0	0	0	195	70	0	0	0
lypa	0	0	0	0	0	0	0	0	0	0	0	0	0
mibi	0	0	0	0	0	0	30	0	0	265	0	0	15
opba	0	0	0	0	0	0	0	5	0	0	0	0	0
pali	0	0	0	0	0	0	0	0	0	0	0	0	0
plri	80	0	0	0	917	0	0	0	0	0	0	0	60
psar	0	0	0	0	0	0	0	40	0	0	0	0	0
pspo	0	0	0	0	0	0	0	0	0	0	0	0	0
same	0	0	0	0	0	0	0	25	0	0	0	0	0
samo	0	0	0	0	0	0	0	0	0	0	0	0	0
sear	5	0	0	0	0	0	0	48	0	0	90	0	0
stpa	0	0	0	0	0	0	0	0	0	0	40	0	0
stsp	0	0	0	0	0	0	0	0	0	0	0	0	0
sumo	0	0	0	0	0	0	0	0	0	0	0	0	0
test	0	0	0	0	0	0	0	0	0	0	0	0	0
thmo	0	0	0	0	0	0	0	0	10	70	0	0	0
xyto	0	0	0	0	0	0	0	0	130	0	0	0	0
Total	425	495	1520	920	2412	435	540	1521	2570	1475	645	1558	1414

Appendix G (continued)

Transects													
species	T123	T127	T129	T130	T140	T141	T144	T145	T146	T147	T148	T151	T154
acsp	0	0	0	0	0	0	0	0	0	0	0	0	10
adco	85	0	0	0	0	0	0	0	0	0	0	0	0
amdu	0	71	1762	90	80	0	0	0	790	0	408	290	0
arsp	0	0	0	0	0	0	0	0	0	0	0	0	0
atca	0	0	0	0	0	0	0	0	0	0	0	0	0
atco	0	0	0	0	0	0	0	0	0	0	0	0	0
atpo	0	0	0	0	0	0	400	0	0	0	0	0	0
atsp	0	0	0	0	0	0	0	0	0	0	0	0	0
chte	0	0	0	0	0	0	0	0	0	0	0	0	0
cora	0	0	0	0	0	0	0	0	0	0	0	0	0
crca	0	0	0	0	0	0	0	0	0	0	0	0	0
ecpo	0	0	0	0	0	0	0	0	0	0	0	0	0
enac	0	0	0	0	0	0	0	0	0	0	0	0	0
enfa	0	0	0	0	0	0	0	0	0	0	0	0	0
enfr	0	0	0	0	0	0	0	0	0	0	0	55	0
epca	0	0	0	0	0	0	0	0	0	0	0	0	0
epne	0	0	0	0	0	0	0	0	0	0	0	0	90
epvi	0	0	0	0	0	0	0	0	0	0	0	0	0
erco	0	0	0	0	0	0	0	0	0	0	0	0	95
ercu	0	0	0	0	0	0	0	0	0	0	0	0	0
erfa	0	0	0	0	0	0	0	0	0	0	0	0	0
grsp	0	0	0	0	0	0	0	0	0	0	0	0	0
gumi	0	0	0	0	0	0	0	0	0	0	0	0	0
hyse	260	0	0	758	0	0	0	0	0	0	0	0	205
krer	0	45	0	0	0	0	0	0	0	0	60	0	0
krla	0	0	0	0	0	0	0	0	0	0	0	0	0
latr	620	376	836	585	110	0	0	0	618	1544	918	115	1110
lefr	0	0	0	0	0	0	0	0	0	0	0	0	0
lepu	0	0	0	0	0	0	0	0	0	0	0	0	0
lyan	0	0	0	100	0	0	0	0	0	0	0	0	30
lypa	0	0	0	0	0	0	0	0	0	0	0	0	0
mibi	0	0	0	40	0	0	0	0	0	0	0	0	0
opba	0	0	0	0	0	0	0	0	0	0	0	0	0
pali	0	0	0	0	0	0	0	0	0	0	0	0	0
plri	0	0	0	0	430	330	0	0	0	0	0	45	0
psar	0	0	0	0	0	0	0	0	0	0	0	0	0
pspo	0	0	0	0	0	0	0	0	0	0	0	0	0
same	0	0	0	0	0	0	0	0	0	0	0	0	450
samo	0	0	0	0	0	0	0	0	0	0	0	0	0
sear	280	0	0	0	0	0	0	0	0	0	0	50	0
stpa	0	0	0	0	0	0	0	85	0	0	0	0	0
stsp	0	0	0	0	0	0	0	0	0	0	0	0	0
sumo	0	0	0	0	0	0	60	0	0	0	0	0	0
test	0	0	0	0	0	0	0	0	0	0	0	0	0
thmo	0	0	0	145	0	0	0	0	0	73	0	0	0
xyto	0	28	0	0	0	0	0	0	0	0	0	0	0
Total	1245	520	2598	1718	620	330	460	85	1408	1617	1386	555	1990

Appendix G (continued)

species	Transects												
	T155	T159	T160	T161	T163	T164	T165	T166	T167	T169	T171	T173	T174
acsp	0	0	0	0	0	0	0	0	0	0	0	0	0
adco	0	0	0	0	0	0	0	0	0	0	0	35	0
amdu	363	220	895	96	81	26	179	223	0	225	0	210	52
arsp	0	0	0	0	0	0	0	0	0	0	0	0	0
atca	0	0	0	0	0	0	0	0	0	0	0	0	0
atco	0	0	0	0	0	0	0	0	0	0	0	0	0
atpo	0	0	0	0	0	0	0	0	0	0	0	0	0
atsp	0	0	0	0	0	0	0	0	0	0	0	0	0
chte	0	0	0	0	0	0	0	0	0	0	0	0	0
cora	0	0	0	0	0	123	0	280	0	0	0	0	0
crca	0	0	0	0	0	0	0	0	0	0	0	0	0
ecpo	0	0	0	0	0	0	0	0	0	0	0	0	0
enac	0	0	0	0	0	0	0	100	0	0	0	0	0
enfa	0	0	0	0	0	0	0	0	0	0	0	0	0
enfr	0	0	0	0	0	0	0	0	0	0	0	0	0
epca	0	0	0	0	0	0	0	0	0	0	0	0	0
epne	0	0	0	0	0	73	0	0	0	0	0	95	0
epvi	0	0	0	0	0	0	0	0	0	0	0	0	0
erco	0	0	0	0	0	71	0	0	0	0	0	0	0
ercu	0	0	0	0	0	0	0	0	0	0	0	0	0
erfa	0	0	0	0	0	0	0	0	0	0	0	75	0
grsp	0	0	0	0	0	0	0	0	0	0	0	0	0
gumi	0	0	0	0	0	0	0	0	0	0	0	0	0
hysa	0	25	0	0	0	134	20	0	0	0	35	212	0
krer	0	0	0	0	0	0	0	39	0	0	245	75	0
krla	0	0	0	0	0	0	0	0	0	0	0	0	0
latr	25	250	859	160	200	1635	295	513	94	195	775	1258	807
lefr	0	125	0	0	0	0	0	0	0	0	0	0	0
lepu	0	0	0	0	0	0	0	0	0	0	0	0	0
lyan	0	0	0	0	0	198	0	0	0	0	0	10	0
lypa	0	0	0	0	0	0	0	0	0	0	0	0	0
mibi	0	0	21	0	0	0	55	47	0	0	0	0	0
opba	0	0	0	0	0	0	0	0	0	0	0	0	0
pali	0	0	0	0	0	0	0	0	0	0	0	0	0
plri	0	0	0	0	0	0	0	0	0	0	0	0	0
psar	0	0	0	0	0	0	0	0	0	0	0	0	0
pspo	0	103	0	0	0	0	0	0	0	0	0	0	0
same	0	0	0	0	0	0	0	0	0	0	0	0	0
samo	0	0	0	0	0	0	0	0	0	0	0	0	0
sear	0	0	0	0	0	0	0	0	0	0	0	0	0
stpa	0	0	0	55	0	0	0	0	126	0	0	0	0
stsp	0	0	0	0	0	0	0	0	0	0	0	0	0
sumo	0	0	0	0	0	0	0	0	0	0	0	0	0
test	0	0	0	0	0	0	0	0	0	0	60	0	0
thmo	0	0	0	0	0	0	0	30	0	0	0	0	0
xyto	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	388	723	1775	311	281	2260	549	1232	220	420	1115	1970	859

Appendix G (continued)

species	Transects												A1
	T176	T178	T180	T183	T185	T189	T193	T195	T196	T198	T199	T200	
acsp	0	30	0	0	0	0	0	0	0	80	173	0	80
adco	0	0	0	0	0	0	0	0	0	0	0	0	0
amdu	1060	1960	430	282	120	873	238	322	190	195	1733	760	210
arsp	0	0	0	0	0	0	0	0	0	0	0	0	0
atca	0	0	0	0	0	0	0	0	0	0	0	0	0
atco	0	0	0	0	0	0	0	0	0	0	0	0	0
atpo	-20	0	0	0	0	0	0	0	0	0	0	0	0
atsp	0	0	0	0	0	0	0	0	0	0	0	0	170
chte	0	0	0	0	0	0	0	0	0	0	0	0	0
cora	0	0	0	0	10	0	0	0	0	0	0	0	0
crca	0	0	0	0	0	0	0	0	0	0	0	0	0
ecpo	0	0	0	0	0	50	0	0	0	0	0	0	0
enac	0	0	0	110	176	0	0	0	0	0	0	0	0
enfa	0	0	0	40	0	0	0	0	0	0	0	0	0
enfr	0	0	0	0	0	0	0	0	0	0	0	0	0
epca	0	0	0	0	0	0	0	0	0	0	0	50	0
epne	0	0	0	185	25	0	0	0	0	0	0	0	0
epvi	0	0	0	0	0	0	0	0	0	0	0	0	0
erco	0	0	0	0	60	0	0	0	0	0	92	0	0
ercu	0	0	0	0	0	0	0	0	0	0	0	0	0
erfa	0	0	0	280	350	0	0	0	0	0	0	0	0
grsp	0	100	0	495	0	0	0	0	0	0	89	0	0
gumi	0	0	0	0	0	0	0	0	0	0	0	0	0
hysa	0	0	70	45	95	0	0	10	55	0	0	170	0
krer	0	0	0	115	165	542	0	0	25	0	0	0	0
krla	0	0	0	0	0	0	0	0	0	0	0	0	20
latr	1010	650	340	0	385	330	187	247	0	420	901	390	350
lefr	0	0	0	0	0	0	0	0	0	0	0	0	0
lepu	0	0	0	0	0	0	0	0	0	0	0	0	0
lyan	0	0	0	95	95	0	0	0	0	0	72	0	150
lypa	0	0	0	0	0	0	0	0	0	0	0	0	0
mibi	20	0	0	10	125	1	0	0	0	0	40	0	0
opba	0	0	0	0	0	0	0	0	0	0	0	0	0
paii	0	0	0	0	0	0	0	0	0	0	0	0	0
plri	0	0	0	0	0	0	0	0	0	0	0	0	0
psar	0	0	0	80	0	0	0	0	0	0	0	150	0
pspo	0	0	0	0	0	0	0	0	0	0	0	0	0
sama	0	0	0	0	470	0	0	0	0	0	0	0	0
samo	0	0	0	0	50	0	0	0	0	0	0	0	0
sear	0	0	0	0	0	0	0	0	155	0	0	0	0
stpa	0	0	0	35	0	58	0	0	0	0	0	0	0
stsp	0	0	0	0	0	0	0	0	0	0	0	0	0
sumo	0	0	0	0	0	0	0	0	0	0	0	0	0
test	0	0	0	0	0	0	0	0	0	0	0	0	0
thmo	0	0	0	0	0	0	0	0	0	0	0	0	30
xyto	50	0	0	0	0	0	0	0	0	0	0	0	0
Total	2120	2740	840	1772	2126	1854	425	579	425	695	3100	1520	1010

Appendix G (continued)

species	Transects								
	A2	A3	A4	A5	A6	A7	A8	A9	A10
acsp	0	0	0	0	0	0	0	0	0
adco	0	0	0	0	0	0	0	0	0
amdu	410	610	0	0	17	0	469.5	0	0
arsp	0	0	0	0	0	0	0	0	0
atca	0	0	0	0	0	0	0	0	0
atco	0	670	860	0	0	0	0	0	0
atpo	0	0	0	0	0	0	0	0	409
atsp	0	0	0	0	0	0	0	0	0
chte	0	0	0	0	100	0	0	0	0
cora	0	0	0	0	0	0	0	0	0
crca	0	0	0	0	0	0	0	0	0
ecpo	0	0	0	0	0	0	0	0	0
enac	0	0	0	0	0	29	0	0	0
enfa	0	0	0	0	0	0	0	0	0
enfr	0	0	0	0	0	0	0	0	0
epca	0	0	0	60	0	0	0	0	0
epne	0	30	0	0	25	0	0	0	0
epvi	0	0	0	0	0	0	0	0	0
erco	0	0	0	0	9	0	0	0	0
ercu	0	0	0	0	0	9	0	0	0
erfa	0	0	0	0	12	94	0	0	0
grsp	0	140	0	0	515	0	0	0	0
gumi	0	0	0	0	81	143	0	0	0
hyss	0	0	0	40	0	0	0	30	0
krer	0	60	0	40	0	0	0	0	0
krla	0	90	0	20	0	0	0	0	0
latr	650	360	0	1070	0	0	1127	686	0
lefr	0	0	0	0	0	0	0	0	0
lepu	0	0	0	0	0	32.5	0	0	0
lyan	0	70	0	0	0	0	50	0	0
lypa	0	0	0	0	0	0	0	0	0
mibi	0	0	0	0	0	0	0	0	0
opba	0	0	0	0	0	0	0	0	0
pali	0	0	0	0	0	0	0	0	0
plri	0	0	0	0	0	0	0	0	0
psar	0	0	0	0	0	0	0	0	0
pspo	0	0	0	0	0	0	0	0	0
same	0	0	0	0	203	23.5	0	0	0
samo	0	0	0	0	0	0	0	0	0
sear	0	0	0	0	0	0	0	0	0
stpa	0	0	0	0	115	9.5	0	0	0
stsp	0	0	0	0	0	0	0	0	0
sumo	0	0	0	0	0	0	0	0	0
test	0	50	0	0	0	0	0	0	0
thmo	0	80	0	0	57	1	0	19.5	0
xyto	0	10	0	0	0	0	0	0	0

Total 1060 2170 860 1230 1134 341.5 1647 735.5 409

Appendix H.

Plant communities of Fort Irwin NTC.

Based partly on analyses by TWINSpan and DECORANA for 113 transects and on field observations for sites that have not been quantitatively sampled, noting dominant (D) perennial species and common shrubs (C) on those transects. Also listed from a different study (Gibson, Prigge, and Niessen, 1994) are perennial that were too sparse (S) to be included in the strip quadrats.

Galleta Grass Sand Fields

D: *Pleuraphis rigida*

C: *Ambrosia dumosa*, *Croton californicus* var. *mojavensis*, *Ephedra californica*

S: *Larrea tridentata*, *Senna armata*, *Krameria erecta*, *Lycium andersonii*, *Lycium pallidum* var. *oligospermum*, *Mirabilis bigelovii*, *Senecio flaccidus* var. *monoensis*, *Hymenoclea salsola*, *Achnatherum hymenoides*, *Encelia frutescens*, *Lepidium fremontii*, *Opuntia echinocarpa*, *Brickellia incana*, *Petalonyx thurberi*, *Hesperocallis undulata*, *Tiquilia plicata*

Substrate: sand

Elevation: below 900 m

Habitat: stable sand fields

Saltbush Scrub

D: *Atriplex confertifolia* and/or *A. spinifera*

C: *Atriplex polycarpa*, *A. canescens*, *Krascheninnikovia lanata*, *Artemisia spinescens*, *Lycium andersonii*, *Hymenoclea salsola*, *Ambrosia dumosa*

S: *Acamptopappus sphaerocephalus*, *Yucca brevifolia*, *Sphaeralcea ambigua*, *Suaeda moquinii*, *Atriplex parryi*, *Grayia spinosa*, *Lepidium fremontii*, *Xylorhiza tortifolia*, *Ephedra nevadensis*, *Larrea tridentata*

Substrate: loam, clay loam, usually moderately alkaline

Elevation: 500-1000 m

Habitat: dry lake margins

Allscale Scrub

D: *Atriplex polycarpa*

C: *Suaeda moquinii*, *Atriplex confertifolia*

S: *Larrea tridentata*, *Ambrosia dumosa*, *Atriplex hymenelytra*

Substrate: loam, sandy loam, not as alkaline as substrates of saltbush scrub

Elevation: 400-950 m

Habitat: valley floor, (slope)

Appendix H. (continued)

Shadscale-Creosote Bush Scrub

D: *Atriplex confertifolia*, *Larrea tridentata*

C: *Eriogonum fasciculatum* ssp. *polifolium*, *Achnatherum speciosum*, *Lycium andersonii*, *Ephedra nevadensis*, *Krascheninnikovia lanata*, *Ambrosia dumosa*

S: *Opuntia basilaris*, *Krameria erecta*, *Xylorhiza tortifolia*, *Grayia spinosa*, *Echinocactus polycephalus*, *Chrysothamnus teretifolius*

Substrate: rocky volcanic sandy loam

Elevation: 1000-1500 m

Habitat: mesas

Blackbush Scrub

D: *Coleogyne ramosissima*

C: *Ephedra nevadensis*, *E. viridis*, *Hymenoclea salsola*, *Eriogonum fasciculatum* ssp. *polifolium*, *Encelia actonii*, *Lycium andersonii*, *Grayia spinosa*, *Xylorhiza tortifolia*

S: *Ericameria linearifolia*, *Opuntia echinocarpa*, *O. basilaris*, *Brickellia arguta*, *Chrysothamnus teretifolius*, *Thamnosma montana*, *Echinocactus polycephalus*, *Echinocereus engelmannii*, *Krameria erecta*, *Salazaria mexicana*

Substrate: rocky or gravelly sandy loam, loamy sand, decomposed granite

Elevation: 1200-1700 m

Habitat: slopes

Blackbush-Creosote Bush Scrub

D: *Coleogyne ramosissima*, *Larrea tridentata*, *Ambrosia dumosa*

C: *Salazaria mexicana*, *Eriogonum fasciculatum* ssp. *polifolium*, *Yucca brevifolia*, *Encelia actonii*, *Ericameria cooperi*, *Lycium andersonii*, *Ephedra nevadensis*, *Hymenoclea salsola*, *Krameria erecta*

Substrate: decomposed granite, sandy loam, loamy sand

Elevation: 1100-1300 m

Habitat: upper alluvial fans

Creosote Bush Scrub

D: *Larrea tridentata*, *Ambrosia dumosa*

C: *Hymenoclea salsola*, *Krameria erecta*, *Mirabilis bigelovii*, *Ephedra nevadensis*, *Thamnosma montana*, *Achnatherum speciosum*, *Psoralea arborescens*, *P. polydenius*, *Lycium andersonii*, *Krascheninnikovia lanata*, *Grayia spinosa*, *Encelia farinosa*, *Stephanomeria pauciflora*, *Tetradymia stenolepis*, *Xylorhiza tortifolia*, *Acamptopappus sphaerocephalus*

Substrate: sand, loamy sand, often gravelly to rocky

Elevation: below 1100 m

Habitat: flats alluvial fans, slopes

Appendix H. (continued)

Cheesebush-Senna Scrub

D: *Hymenoclea salsola*, *Senna armata*, *Larrea tridentata*

C: *Ambrosia dumosa*

Substrate: sand, gravelly sand

Elevation: below 1100 m

Habitat: washes and arroyos

Juniper Woodland

D: *Juniperus osteosperma*, *Coleogyne ramosissima*, *Ephedra viridis*, *Eriogonum fasciculatum*, *Achnatherum speciosum*

C: *Kraescheninnikovia lanata*, *Grayia spinosa*, *Gutierrezia microcephala*, *Ephedra nevadensis*, *Chrysothamnus teretifolius*, *Galium stellatum*, *Salvia pachyphylla*, *Elymus elymoides*, *Achnatherum hymenoides*, *Eriogonum heermannii*

Substrate: rocky sandy loam

Elevations: above 1700 m

Habitat: slopes and ridges

Alkali Sink (only one site known, W of Bitter Spring)

D: *Allenrolfea occidentalis*, *Suaeda moquinii*

C: *Atriplex hymenelytra*

Substrate: clayey loam, loamy clay, alkaline

Elevations: 420 m

Habitat: saline playa margins

Mixed Desert Scrub

D: generally lacks a conspicuous dominant

C: *Eriogonum fasciculatum*, *Larrea tridentata*, *Coleogyne ramosissima*, *Galium stellatum*, *Achnatherum speciosum*, *Elymus elymoides*, *Gutierrezia microcephala*, *Brickellia arguta*, *Ericameria cooperi*, *Xylorhiza tortifolia*

Substrate: decomposed granite, sandy loam

Elevations: 1100-1300 m

Habitat: rocky, bouldery slopes

Joshua Tree Woodland (good stands may not occur on NTC)

D: *Yucca brevifolia*, *Larrea tridentata*, *Ambrosia dumosa*, *Eriogonum fasciculatum*

C: *Coleogyne ramosissima*

Substrate: no data

Elevations: above 1300 m

Habitat: upper alluvial slopes, plains, and slopes

Appendix I.

Acronyms and Plant Names, Scientific and Common, Used in Report.

<u>Acronym</u>	<u>Scientific Name</u>	<u>Common Name</u>
acsp	<i>Acamptopappus sphaerocephalus</i>	
adco	<i>Adenophyllum cooperi</i>	
amdu	<i>Ambrosia dumosa</i>	burrobush
arsp	<i>Artemisia spinescens</i>	bud sagebrush
atca	<i>Atriplex canescens</i>	fourwing saltbush
atco	<i>Atriplex confertifolia</i>	shadscale
athy	<i>Atriplex hymenelytra</i>	desert-holly
atpo	<i>Atriplex polycarpa</i>	allscale
brar	<i>Brickellia arguta</i>	
chpl	<i>Chamaesyce polycarpa</i>	
chsp	<i>Chenopodium sp.</i>	
chte	<i>Chrysothamnus teretifolius</i>	needle-leaf rabbitbrush
cora	<i>Coleogyne ramosissima</i>	blackbush
crca	<i>Croton californicus</i>	
ecpo	<i>Echinocactus polycephalus</i>	cottontop
enac	<i>Encelia actonii</i>	
enfa	<i>Encelia farinosa</i>	brittlebush
enfr	<i>Encelia frutescens</i>	
envi	<i>Encelia virginensis</i>	Virgin River brittlebush
epca	<i>Ephedra californica</i>	desert-tea
epne	<i>Ephedra nevadensis</i>	nevada-tea
epvi	<i>Ephedra viridis</i>	green ephedra
erco	<i>Ericameria cooperi</i>	goldenbush
ercu	<i>Ericameria cuneata</i>	
erfa	<i>Eriogonum fasciculatum</i>	Calif. buckwheat
grsp	<i>Grayia spinosa</i>	hog-sage
gumi	<i>Gutierrezia microcephala</i>	match-stick bush
hysa	<i>Hymenoclea salsola</i>	cheesebush
krer	<i>Krameria erecta</i>	Pima rhatany
krla	<i>Krasheninnikovia lanata</i>	winter fat
latr	<i>Larrea tridentata</i>	creosote bush
lefr	<i>Lepidium fremontii</i>	pepper-grass
lepu	<i>Leptodactylon pungens</i>	
lyan	<i>Lycium andersonii</i>	box thorn
lypa	<i>Lycium pallidum oligosperma</i>	
mibi	<i>Mirabilis bigelovii</i>	wishbone herb
opba	<i>Opuntia basilaris</i>	beavertail cactus
paar	<i>Palafoxia arida arida</i>	Spanish needles
plri	<i>Pleuraphis rigida</i>	galleta grass
poa	<i>Poa sp.</i>	
psar	<i>Psoralea arborescens</i>	Mojave indigo bush
pspo	<i>Psoralea polydenius</i>	spotted dalea
same	<i>Salazaria mexicana</i>	bladder sage
samo	<i>Salvia mohavensis</i>	
sear	<i>Senna armata</i>	armed senna

Appendix I (continued)

<u>Acronym</u>	<u>Scientific Name</u>	<u>Common Name</u>
stpa	<i>Stephanomeria pauciflora</i>	wire lettuce
stsp	<i>Achnatherum speciosum</i>	needlegrass
sumo	<i>Suaeda moquinii</i>	seep weed
test	<i>Tetradymia stenolepis</i>	Mojave cotton-thorn
thmo	<i>Thamnosma montana</i>	turpentine broom
xyto	<i>Xylorhiza tortifolia</i>	desert aster
yubr	<i>Yucca brevifolia</i>	Joshua tree